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Interrelationships of Childhood Overweight, School Performance and Self-esteem among Canadian Children

by

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A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

Public Health Sciences

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Abstract

Childhood overweight has become epidemic and its prevalence rate continues to increase. The consequences of childhood overweight for physical health are broadly documented, however, relatively little research has examined consequences for mental health. As previous studies have suggested that childhood overweight, self-esteem and school performance are interrelated, it is beneficial to study these factors simultaneously. The objectives of the present thesis were (1) to classify the directionality of the associations between overweight, school performance and self-esteem; (2) to examine the temporal relationships between overweight, school performance and low self-esteem; (3) to reveal the potential mechanisms of the associations between body weight, school performance and self-esteem; (4) to examine the longitudinal impacts of changes in 2-year late body weight and school performance on 4-year late self-esteem. Two sources of data were used: the first one was a provincial survey data from Children's Lifestyle And School-performance Study (CLASS) in Nova Scotia, Canada. The second one was a national data of Canada National Longitudinal Survey for Children and Youth (NLSCY). Results: With the CLASS data, cross-sectional Structural Equation Modeling (SEM) revealed the directions of the associations and showed that body weight affected self-esteem negatively and that school performance affected self-esteem positively. Body weight did not affect school performance and self-esteem did affect neither body weight nor school performance. Subsequent logistic regression found that obese children and children with poor school performance, relative to normal weight children and those performing good, were more likely to report low self-esteem respectively. With the NLSCY data, cross-sectional regression reconfirmed the results of the CLASS data demonstrating that obese

children and children performing poor were at higher risk of low self-esteem. Longitudinal investigation found that childhood obesity preceded low self-esteem, whereas low self-esteem did not predict excess weight. Furthermore, by using SEM, cross-sectional analysis reconfirmed our observations of the CLASS data showing that increased body weight and decreased school performance affected the level of self-esteem. Longitudinal analysis found that change of 2-year late body weight did not affect 4-year late self-esteem, whereas change of 2-year late school performance had a significantly positive effect on 4-year late self-esteem.

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Chapter 1 – Introduction

1.1.0 Overview

Childhood obesity rates have dramatically increased in the past decades. (1) In 2004, in Canada, about 26% of children were overweight or obese, and 8% of children were obese. (2) Overweight and obese children are at an increased risk of developing a number of adulthood diseases such as hypertension, type II diabetes, and cardiovascular disease (CVD) and cancers. (3, 4) However, the results of current studies addressing the impacts of childhood overweight and obesity on psychological well-being were inconsistent. The presence of childhood overweight and obesity has been suggested to negatively impact on self-esteem, (5, 6) school performance, (7) behaviors and emotional development, (8-10) but other authors reported no associations. (11, 12) Self-esteem is one of the prominent components of mental health and personality development. (13, 14) Childhood self-esteem is often referred to as an early marker of mental health in adulthood, since self-esteem plays an essential and important role in children's social, emotional, behavioral and mental development. (15) Low self-esteem hampers social and cognitive development in children and may lead to poor health outcomes in adulthood. (16-19) Poor school performance will result in limited educational attainment, impaired career opportunities and in the long-term lower socioeconomic status with reduced prospects for good health. (20-22) As previous studies have suggested that childhood overweight, self-esteem and school performance are interrelated, it is beneficial to study these factors simultaneously and further classify whether childhood overweight affects self-esteem and school performance or visa versa. If the childhood overweight epidemic continues and overweight negatively affects self-esteem and school performance, one can expect to see more mental health problems and less educational attainment adding to the health burden in adulthood and that of future generations. Clarifying the interrelations of childhood overweight, self-esteem and school performance could improve the understanding of the psychological consequences of overweight and confirm if overweight is an important risk factor for low self-esteem and poor school performance. Furthermore, in order for a population intervention strategy to be effective, good evidence of causal relationships between these factors is needed. Such information is necessary to provide direction for future research and preventive policy.

1.2.0 Measurement and Definition of Childhood Overweight and Obesity

Excess body weight can be quantified in various ways, for example, underwater weighing (hydrodensitometry), dual energy x-ray absorptiometry, bio-impedance analysis, deuterium oxide dilution, and skin-fold thickness. (23, 24) Although accurate, these methods are expensive, time-consuming, and impractical for population surveillance. (25) In adults, the prevalence of overweight and obesity is commonly assessed by calculating body mass index (BMI). BMI shows significant variations during childhood. (26-28) Therefore, it is necessary to have age- and gender-specific cut-offs of BMI for children and adolescents. The International Obesity Task Force (IOTF) developed such age- and gender-specific cut-offs of BMI for 2-18 years. (29, 30) These cut-offs were based on measured height and weight in children from five countries in previously conducted surveys. Each survey had over 10,000 subjects. (29) The cut-offs are based on health related adult definitions of overweight ($\geq 25 kg/m^2$) and obesity ($\geq 30 kg/m^2$), but are adjusted to specific age and gender categories for children. (29) The IOTF cutoffs were published in 2000 and are now widely used. Adoption of the IOTF cutoffs will better allow comparisons to be made between countries and over time. (31,32) There are many studies still use $\geq 95^{th}$ percentile of national or population-specific distributions to define obesity and $\geq 85^{th}$ percentile to define overweight, (32,33) as some reports indicated that the IOTF cutoffs averaged data from different counties and the choice of reference ages, which could be underestimate the prevalence. (34-38)

1.3.0 Childhood Self-esteem and Assessment

Defining self-esteem has proven to be a difficult task and a number of definitions have been put forth. William James defined self-esteem as a balance between a person's reality-based attainments and his or her goals or aspirations. (6) Rosenberg defined self-esteem as self-acceptance, a basic feeling of self-worth. (39) Other authors indicated that self-esteem generally referred to how we feel about or how we value ourselves, and it is the opinion and perception one has of himself, and refers to a person's evaluation of, or attitude toward himself in most situations and most of the time in terms of personal attributes such as ability, worth, and limitations. (6, 40, 41) Self-esteem is not innate. It is developed or constructed by the individual through interaction with the environment and

reflecting on that interaction. It is learned, organized, and dynamic and can be changed or modified. (42) Whether we have high or low self-esteem depend at least part on how others regard and treat us. (43)

According to the multidimensional, hierarchical model advocated by leading researchers self-esteem could be assessed by incorporating components such as the global self (or self-esteem): a person's overall positive versus negative feelings about the self, the physical appearance self (or body esteem/satisfaction), the athletic self, the academic self, the social self , the occupational self and the family self. (44, 45) Based on the Shavelson's model, self-esteem has three identifiable levels. The top is global or general self-esteem; the middle level are specific sectors of self-esteem such as academic self-esteem; and the bottom level are specific sub-areas of self-esteem such as mathematics self-esteem, language self-esteem, etc. (46, 47) Within the hierarchical organization, global self-esteem is relatively stable and enduring compared with other domain self-evaluations. Based on the corresponding theories, some self-esteem measurement scales only measure the global self-esteem; others measure both global self-esteem and sub-components.

There are a lot of measurement scales for children's self-esteem and several ones are very popular. The most popular one is Rosenberg Self Esteem Scale (RSEI, Rosenberg, 1965), which is a 10-item scale designed to measure the global self-esteem. Scores range on the lower end from 1.0 representing poor self-esteem, to 4.0 representing very positive self-evaluations. This Self-Esteem Scale was originally developed for high school students, but it has been used extensively with older groups of adults. With regard to validity, Rosenberg reported significant correlations between self-esteem and clinical ratings of depression (39). The Harter Self-Perception Profile for Children (Harter, 1985), the most widely used self-esteem scale for children aged 8-14 years old, is also a self-administered questionnaire, which includes six areas believed to be important for self-esteem and there are six items in each area. The six areas are scholastic competence, social acceptance, athletic competence, physical appearance, behavioral conduct, and global self-worth. Items are scored from 1 to 4, where 4 represents the most adequate self-judgment and 1

the least. The internal consistency reliability was from 0.80 to 0.94. (48, 49) Construct validity was not satisfied. (49) Different self-designed individually administered questionnaires were popularly used to assess childhood self-esteem. (50, 51) Even a single item was reported to provide a valid measure of global self-esteem. (52)

1.4.0 How to Define Low Self-esteem in Children?

Low self-esteem refers to a person who has a negative attitude, poor feeling and devalues himself. (53) It can have devastating consequences, for example, to create anxiety, stress, loneliness and increased likelihood for depression, to cause problems with friendships and relationships, and may lead to underachievement and increase vulnerability to drug and alcohol abuse (54-57). Worst of all, these negative consequences themselves reinforce the negative self-image and increasingly non-productive or even actively self-destructive behavior (58). Most people have an image of what low self-esteem looks like, but it is not always so easy to recognize. As self-esteem generally is measured on self reported ordinal scales and may follow a non-normal distribution, nonparametric statistics are usually used. Generally low self-esteem could be defined as total questionnaire score falling below the 15^{th} percentile or below 10^{th} percentile, which is close to the parametric concept of one standard deviation below the mean (59-61).

1.5.0 The Previous Study of Childhood Overweight, Self-esteem and School performance

1.5.1 Childhood Overweight and Self-esteem

Previous studies have focused either on association between obesity and self-esteem (5, 6), between school performance and self-esteem (62, 63), or between obesity and school performance (7). Childhood overweight and obesity is reported to affect the development of self-esteem. The conclusion obtained from a review that included 35 studies by French and colleagues in 1995 indicated that there was a modest inverse association between obesity and low self-esteem. (5) Another review covering 28 more recent studies published in 2005 by Wardle and Cooke came to the same conclusion as French. (6) Although there are some obvious inconsistencies, (11, 64-68) the majority of cross-

sectional studies reported that obese boys and girls were at a modest risk of low self-esteem, (69-73) and there was a weak to moderate inverse correlation between overweight and self-esteem. Some subgroups were more vulnerable than others. That is adolescents, girls, whites and clinical samples were more affected than younger children, boys, children in minority groups and community samples. Age, gender, race, culture, socioeconomic status and other socio-psychological factors, such as weight-related teasing, can be important moderators of the association. (5, 6, 74, 75) A small body of longitudinal studies showed that the increases in BMI were significantly associated with unfavorable changes in self-esteem. (43, 59-61, 76, 77) Children who were overweight and obese at baseline had lower self-esteem at follow-up. (6, 59) Low self-esteem did not appear to predict the development of obesity. (6) One prospective study in black children and another one in white adolescent females suggested that high self-esteem was protective against increases in BMI over time, but low self-esteem at baseline did not significantly increase overweight at follow up. (74) According to the follow-up studies above, we see that the increases in BMI were significantly associated with unfavorable changes in self-esteem. (43, 59-61, 76, 77) Compared with non-obese girls, global and scholastic self-esteem significantly decreased in obese girls over time. Only one study indicated that overweight preceded low self-esteem (59), and another one reported that low self-esteem did not appear to predict the development of obesity over time. (43)

1.5.2 Childhood Overweight and School Performance

Fewer studies focused on the association between overweight and school performance and the conclusion is inconsistent. Some authors reported that there was a negative association between overweight or obesity and school performance, others disagreed with them. From a recent review, the authors reported that comparing to their normal weight peers, overweight and obese children and adolescents generally perform more poorly when academic achievement and school attendance were measured. (7) However, the findings from Tershakovec, Weller and Gallagher showed that after controlling for birth weight, age, sex, family income, and school absences, there was no association between obesity and classroom failure in 3rd- and 4th-grade children. (78) Furthermore, Zoppi et al. reported that obese children had higher school performance comparing to normal children

because obese children attended school more diligently in order to counterbalance their negative self-esteem. (79) Considering that the findings of above studies were inconsistent, we suggest conducting more studies to further investigate the association between overweight/obesity and school performance.

1.5.3 School Performance and Self-esteem

Most previous studies have reported that self-esteem is positively correlated with school performance. (63, 64, 80-82) There are several plausible reasons that link high self-esteem to good school performance, since high self-esteem may help people to set higher aspirations and foster the confidence to deal with difficult problems. People with high self-esteem may be more willing to persist in the face of initial failure. (62) In their review covering12 cross sectional and 6 longitudinal studies, Baumeister and colleagues concluded that self-esteem is a result, not a cause, of doing well in academic or school performance; and that any correlations between self-esteem and achievement are likely to be due to third variables such as family background and abilities. (62) At the same time, self-esteem has a very weak or no impact on subsequent school performance. (80) We notice that none of above studies considered and included subjects' weight status. We only found one earlier study which considered obesity, self-esteem and school performance simultaneously (63). This study reported that higher body mass index (BMI) was associated with lower self-esteem and poorer grades among high school students (63). No earlier study has reported on the interrelations of obesity, self-esteem and school performance among younger children.

1.6.0 Summary

Childhood obesity increases the risk for various chronic diseases resulting in decreases in life expectancy and quality of life. (70, 73) The influence of childhood obesity on mental health and school performance has been less studied. There is a large body of empirical literature concerning the associations between obesity and self-esteem, between obesity and school performance, and between school performance and self-esteem, but few studies reported the associations of obesity, self-esteem and school performance simultaneously, and had linked those associations to causal relationships. Interpretations

of existing studies were partly hampered by small study samples, lack of appropriate control groups, different methodological approaches, employed diverse school performance and self-esteem instruments. The present study will provide new evidence to enhance the understanding of the psychological and school performance consequences of childhood obesity, and suggest the convictive information for developing effective interventions.

1.7.0 Objectives

This thesis aims to reveal the interrelationships of childhood body weight, school performance and self-esteem after controlling for potential confounders. The study will answer the following questions at the population level:

1. To classify the directionality of the associations between body mass index, school performance and self-esteem in children simultaneously.

2. To study the cross-sectional associations and temporal relationships between childhood overweight, school performance and self-esteem.

3. To reveal the underlying mechanisms of the associations of body mass index, school performance and self-esteem, in addition to reconfirm the directions of the associations and compare the results of two different studies.

4. To examine the longitudinal impacts and potential mechanisms of changes in 2-year late body mass index and school performance on 4-year late self-esteem.

1.8.0 Structure of the Thesis

This thesis was organized as follows: The first study (Chapter 2) involved a provincial cross-sectional survey data of the 2003 Children's Lifestyle And School-performance Study (CLASS) in Nova Scotia. From the second study (Chapter 3) to the fourth study (Chapter 5), we used Canadian national longitudinal survey datasets of the first cohort of National Longitudinal Survey for Children and Youth (NLSCY). The first study (Chapter 2) of the thesis provided new evidence of the directionality of the associations between body mass index, school performance and self-esteem, and subsequently revealed the determinants of low self-esteem. In the second study (Chapter 3) of the thesis, cross-sectional (baseline) and longitudinal datasets of the first cohort of NLSCY were used to

reconfirm the cross-sectional associations between overweight, school performance and self-esteem, and further, to study the temporal relationships between overweight, school performance and self-esteem. In Chapter 4, a short study, with the baseline survey data of NLSCY, we reconfirmed the observations in Nova Scotia (CLASS) and explained the underlying mechanisms of the associations between body mass index, school performance and self-esteem. In the last part (Chapter 5) of the thesis, longitudinal survey data of NLSCY were used to reveal the longitudinal impacts and underlying mechanisms of changes in 2-year late body mass index and school performance on 4-year late self-esteem.

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Chapter 2: Self-esteem and Cognitive Development in the Era of the Childhood Obesity Epidemic. *

2.1.0 Introduction

Childhood obesity is a major public health problem as it increases the risk for various chronic diseases resulting in decreases in life expectancy and quality of life. (1, 2) The importance of childhood obesity for mental health and cognitive development has been less studied. Self-esteem is one of the basic and important components of mental health and personality development. (3, 4) Low self-esteem may hamper social and cognitive development in children and may lead to poor health outcomes in adulthood. (5) Poor cognitive development may result in limited educational attainment, impaired career opportunities and in the long-term lower socioeconomic status with reduced prospects for good health. (6, 7)

Childhood obesity rates have dramatically increased in the past decades. (8) In Canada in 2004, about 26% of children were overweight or obese, and 8% of children were obese (9). If childhood obesity rates continue to increase, and if childhood obesity has a negative effect on self-esteem and cognitive development, one should expect more mental health problems and less educational attainment adding to the health burden in adulthood and that of future generations. (10)

Previous studies have suggested a modest inverse association between body weight and self-esteem, (11, 12) a positively association between school performance and self-esteem, (13, 14) and a possible association between obesity and school performance. (15) It may be beneficial to study body weight, self-esteem and school performance simultaneously, as studies have suggested that they are interrelated. To date, however, only one earlier study did consider body weight, self-esteem and school performance simultaneously. (14) This study reported that higher body mass index (BMI) was associated with lower self-esteem and with poorer grades among high school students. (14) No earlier study has reported on the interrelationships of obesity, self-esteem and

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school performance among younger children.

In the present study we aim to reveal the directions of the associations among Body Mass Index (BMI), self-esteem and school performance by using Structural Equation Modeling (SEM) and to find the determinants of low self-esteem by using logistic regression among grade five students who are primarily 10 and 11 years old.

2.2.0 Research Design and Methods

2.2.1 Study Design

The 2003 Children's Lifestyle And School-performance Study (CLASS) was a large cross-sectional survey of health, nutrition, school performance, and socioeconomic determinants among grade five students and their parents in the Canadian province of Nova Scotia where more than 95% of the population is of European descent and 98.4% of students attend public school. (16)

2.2.2 Sample

This study targeted fifth grade students since these children would also complete a standardized school performance test. Of the 291 public schools with grade five classes, 282 (96.9%) participated by distributing a consent form and questionnaire to parents of all their fifth grade students. Parental consent was received for 5,517 students, resulting in an average response rate of 51.1 % per school. Trained CLASS representatives visited these schools during school hours to administer the Harvard's Youth Adolescent Food Frequency Questionnaire (YAQ), (17) a student survey with questions on self esteem and physical and sedentary activities, and to measure the heights and weights of participating students. The administration of the surveys and measurement of heights and weights took generally less than 45 minutes to complete. (18)

Ethics Approval

The Health Sciences Human Research Ethics Board of Dalhousie University has approved the original study, including the informed consent procedure. The Health

Research Ethics Board at the University of Alberta has approved the data analysis of the present study.

2.2.3 Measurement and Evaluation

2.2.3.1 Height and Weight

After removing their shoes, CLASS representatives measured standing height to the nearest 0.1 cm and body weight was measured to the nearest 0.1 kg using calibrated digital scales (18). Overweight and obesity were defined by using the international BMI cut-off points established for children and youth by International Obese Task Force (19). These cut-offs are based on health-related adult definitions of overweight ($\geq 25 kg/m^2$) and obesity ($\geq 30 kg/m^2$), but are adjusted to specific age and gender categories for children.

2.2.3.2 School Performance

The Elementary Literacy Assessment is a standardized test administered by the Nova Scotia Department of Education. Completion of the assessment required students to read a variety of materials and answer written questions based on those readings. Materials included a short story, information texts, a poem and a visual media text. Reading and writing assessments were marked centrally by a team of experienced teachers under the supervision of the Nova Scotia Department of Education. Both individual and school-level test results were linked to the CLASS database. The available school performance for reading and for writing included an indicator of 'not meeting the standard', 'meeting the standard' or 'exceeding the standard'. At the school level, we considered the percentage of students meeting or exceeding the standard for both reading and writing as a marker of performance.

2.2.3.3 Questionnaires

2.2.3.3.1 Self-esteem

A large number of instruments have been developed in the past decades to assess self-esteem in distinct groups and for distinct purposes (20,21). From these existing instruments, we selected 11 items suitable for our age group to capture appearance, abilities, emotions, peer acceptance, future hopes and overall life satisfaction levels in a population-based setting. Specifically, we included the following items (i) I like myself;

(ii) I feel like I do not have any friends; (iii) I like the way I look; (iv) My future looks good to me; (v) I feel unhappy or sad; (vi) I worry a lot; (vii) I cry a lot; (viii) I get into physical fights; (ix) I am bullied by other kids; (x) I bully other kids and (xi) I have trouble paying attention. Response choices for each of these items included 'never or almost never', 'sometimes' to 'often or almost always'. We scored these responses as 1, 2 and 3, with the highest score representing good self-esteem, and subsequently totaled the scores (20). The self-esteem score therefore ranges from 11 to 33. The inter-item reliability (Cronbach's alpha) of the 11 items was 0.78.

2.2.3.3.2 Other Influencing Factors

The interrelations between body-weight status, self-esteem and school performance are affected by various factors. We considered the following: child's gender, rural or urban residency, household income, parental education, child's physical and sedentary activity level, diet quality, school neighbourhood income level and school-level academic performance. Age was not considered, as all participants were fifth graders who are primarily 10 and 11 s old. The questionnaire completed by parents provided information on location of residence, household income in four categories (less than CA$20 000, $20 000–$39 999, $40 000–$59 999 and $60 000 or more), and parental education (secondary school or less, community college, university and graduate university). The student survey included validated questions on physical activity and sedentary activity taken from the National Longitudinal Survey for Children and Youth (21). The YAQ is a 147-item food frequency questionnaire modified for use in Canada by using product names that are common in Canada (17). Information obtained through the YAQ and Canadian food tables allows estimation of food and nutrient intakes that in turn are used to calculate the Diet Quality Index-International, a composite measure of diet quality (22). School neighbourhood income level was determined by averaging the postal code level information on household income, available through Census Canada, of students attending the particular school (23).

2.2.4 Data Analysis

2.2.4.1 Distribution and Characteristics of Study Subjects

Distributions and differences in proportions of covariates in study subjects according to three body-weight groups were compared by χ^2 test.

2.2.4.2 The Directions of the Associations between BMI, Self-esteem and School Performance

Structural equation models (SEM) are based on covariance matrices rather than individual observations. Regardless of whether observations are cross-sectional or longitudinal, SEM reveal effects and relationships, although there is some divide among researchers using SEM whether these effects and relationships are causal or not. Importantly, unlike regression methods, SEM allow studying models with more than one outcome variable, such as in our study, where we a priori considered three outcome variables: body weight, self-esteem and school performance. As a first step in our analytic approach, we applied SEM to determine the relationships between body weight, self-esteem and school performance (the three endogenous concepts). We started with trying to confirm a model that included each of the six relational combinations (i) body weight affects self-esteem; (ii) self-esteem affects body weight; (iii) body weight affects school performance; (iv) school performance affects body weight; (v) school performance affects self-esteem and (vi) self-esteem affects school performance. Upon failure to confirm this model, i.e. when the goodness-of-fit χ^2 test statistic revealed a statistically significant difference between the hypothesized model and the observations, we reduced the number of relational combinations by removing the relational combination with the poorest fit. Subsequently, we tried to confirm the reduced model. We repeated this process until we confirmed the existence of a model with a satisfactory goodness of fit. In the above models, we considered the confounding influence of child's gender, rural or urban residency, household income, parental education, child's physical and sedentary activity level, diet quality, school neighbourhood level income, and school-level academic performance (the exogenous concepts) on body weight, self-esteem and school performance.

The application of SEM comes with established limitations (24). For example, endogenous concepts are prefer-ably continuous or ordinal with multiple categories (24). For this reason, we considered BMI as a continuous concept of body weight, self-esteem

score as a continuous concept and school performance as an ordinal concept of five categories. Details are provided in Table 1.

In the present study, unstandardized structural coefficients are reported. Each of the β and γ coefficients retains the usual interpretation that a unit change in the causal variable is expected to be accompanied by β or γ units of change in the dependent variable after controlling for all the other variables in the equation. (24)

2.2.4.3 The Determinants of Low Self-esteem

Given the above limitations and because the results of the SEM justified the use of regression methods (see result section), we applied multi-level regression methods to more accurately quantify the associations of body-weight status and of school performance with self-esteem. Specifically, we applied two-level logistic regression methods with self-esteem as the first-level binary outcome. As the responses to the self-esteem items were ordinal and the sum scores were not normally distributed, we dichotomized the outcome and defined scores lower than the 15th percentile as low self-esteem, which is close to the parametric concept of one standard deviation below the mean and which is commonly applied in self-esteem research (25). In terms of body weight, children were categorized as normal weight, overweight or obese (Table 2-1). Body-weight status and all other child and parent characteristics were considered as first-level covariates. School neighbourhood level income and school-level academic performances were considered as second-level covariates (Table 2-1). Both unadjusted results of a univariate model and adjusted results of a parsimonious multivariate model were presented.

These analyses included 4945 children that had complete information of self-esteem and diet quality. We excluded 234 (4.5%) of the 5200 students with outlying observations based on energy intakes less than 500 kcal or greater than 5000 kcal per day in accordance with established recommendations for outliers in nutritional research (26). We excluded an additional 21 (0.4%) students who had incomplete information of self-

esteem. Missing values for other covariates were considered as separate covariate categories.

The SEM was constructed using LISREL, version 8.0, and the remaining statistical analysis conducted with STATA, version 9.0.

2.3.0 Results

2.3.1 Distribution and Characteristics of Study Subjects

Characteristics of children and information on the distributions and differences in proportions of covariates according to three body-weight groups were showed in Table 2-2. 23.47% of the students were overweight and among them 9.87% were obesity. Totally 18.24% of the students had low self-esteem and 18.50% had poor school performance. When body weight increased, the proportions of low self-esteem and poor school performance increased. For normal weight, overweight and obese children the prevalence of low self-esteem was 16.76%, 19.46% and 25.37% respectively, and the proportions of poor school performance was 17.26%, 18.54% and 23.61%. Obese children had the highest proportions of low self-esteem (25.37%) and poor school performance (23.61%). The distribution of gender, proportions of four different sedentary activity groups, and proportions of three diet quality groups were similar among three body weight groups. The proportion of rural was higher in overweight and obese groups. As household income, parent education, physical activity, and school neighborhood average income increased, the proportions of obesity decreased. The proportions of obesity increased, as school level academic performance failures increased.

2.3.2 The Directions of the Associations between BMI, Self-esteem and School Performance

Our structural equation model confirmed the existence of three interrelations among the three endogenous concepts, two of which were statistically significant. (i) Body weight affected self-esteem whereby an increase of one unit of BMI was associated with a decrease of 0.048 (95% confidence interval [CI]: -0.070, -0.025) in self-esteem score. (ii) School performance affected self-esteem whereby an increase of one unit of school

performance was associated with an increase of 0.609 (95% CI: 0.505, 0.712) in self-esteem score. (iii) The effect of body weight on school performance was not statistically significant ($\beta = 0.003$; 95% CI: -0.010, 0.004). Self-esteem neither affected BMI nor school performance. And school performance did not affect BMI. Table 2-3 shows the associations (and 95% CIs) of the exogenous concepts with each of the three endogenous concepts. Figure 2-1 displays those statistically significant associations of exogenous concepts with endogenous concepts (γ's) and those interrelations between endogenous concepts (β's). Appendix 1 shows the original output of Figure 2-1. Parental education and household income affected BMI, self-esteem and school performance in a statistically significant manner. Physical activity affected self-esteem in a positive manner and sedentary activities affected self-esteem and school performance in a negative manner. Diet quality had a positive effect on school performance (Table 2-3 and Fig. 1). The goodness-of-fit χ^2 test statistic (Table 2-3, P = 0.8003) indicated that the obtained model provides a strong representation of the observations.

2.3.3 The Determinants of Low Self-esteem

We obtained a SEM in which body weight and school performance affect self-esteem but where no other statistically significant relations between the three endogenous concepts exist. This model could be rewritten as a model with a single outcome (self-esteem) and with body weight and school performance as independent variables. Such a model allowed the application of regression methods with self-esteem as the outcome of interest. Table 2-4 shows the unadjusted and adjusted odds ratios for low self-esteem. Relative to normal weight participants, obese children were 1.44 times (95% CI: 1.12 - 1.84) more likely to report low self-esteem. Relative to those not meeting the standard, participants of whom school performance met the standard and exceeded the standard were, respectively, 0.55 (95% CI: 0.46 - 0.67) and 0.39 (95% CI: 0.26 - 0.58) times less likely to report low self-esteem. These differences were statistical significant. Table 2-4 further shows that higher parental education, better diet quality and more physical and less sedentary activities all had a statistically significant positive effect on self-esteem.

2.4.0 Discussion

Self-esteem is an assessment of one's worth and is often used as an indicator of mental well-being (3). Children and youth with low self-esteem generally have negative attitudes and limited capacity to respond to daily and developmental challenges (27, 28). As such, they are more likely to engage in negative behaviors such as school absence, smoking, drinking, and drug use and delinquency, and more likely to experience negative psychological conditions such as anxiety, depression and suicidal behavior (29, 30).

This study is the first population-based study that considered obesity, self-esteem and school performance simultaneously in the young age group of 10 and 11 year olds. We observed that excess body weight has an independent negative effect on self-esteem, which is in agreement with observation of studies that did not include consideration of school performance (12, 31). Our observation of the positive effect of physical activity on self-esteem has also been reported previously (32). However, our observations of the positive effect of diet quality and the negative effect of sedentary activities on self-esteem have not been reported previously. They add to the rationale to promote healthy eating and active living in childhood as this will improve not only physical health, but also mental health. Consistent with our observations, various studies have shown the effects of socioeconomic factors on body weight, self-esteem and school performance (33-36). These findings emphasize the importance of targeting children of socioeconomic disadvantaged families and neighbourhoods.

The present study showed that less physical activity, more sedentary lifestyle, poor diets and excess body weight are all risk factors for low self-esteem. Children in Western countries went through decades of changes towards less physically active and more sedentary lifestyle, deteriorating diets and increased rates of excess body weight. The findings of the present study therefore suggest that as a result of these temporal lifestyle changes, the prevalence of low self-esteem may be increasing over time. Searching the existing literature, however, we were not able to confirm the existence of such a temporal increase in the prevalence of low self-esteem. To the best of our knowledge, there is no documentation on secular trends of low self-esteem in childhood. Other studies, though, did reveal that self-esteem is relatively unstable in childhood (37).

A review article published in 2005 revealed that a relative small number of studies addressed the association between childhood overweight and performance at school and that these studies have been inconsistent in their conclusions whether or not overweight children are more likely to perform poorly relative to their normal weight peers (15). The present study confirms our previous work in which we observed that poor school performance was more common among overweight children, but when considering confounding factors, the association between body weight and school performance vanished (38). A few studies made those same observations (39, 40). Some of these studies had considered health behaviors like physical activity and diet quality, while others considered race and socioeconomic factors. These studies suggest that body weight is just an intermediate step and that physical activity, diet quality, race and socioeconomic factors affect school performance. Promotion of healthy eating and active living with consideration of racial and socioeconomic differences may therefore be beneficial both to prevent chronic diseases and to improve school performance.

The importance of school performance for self-esteem is better established (13, 14). Good school performance makes students feel better and more confident, which in turn may help them set higher aspirations, foster the confidence to deal with difficult problems and provide the willingness or intrinsic motivation to persist in the face of initial failure (13). The findings of the present study are in agreement with these earlier studies.

The strengths of the present study are that it is a large population based study with objective measures of height and weight and included results from standardized literacy test. However, assessment tools for self-esteem are based on self-report and therefore prone to error. In addition, selection bias may have occurred as participation was voluntary and required parental consent, urging caution with generalizing the study observation to the population at large. We applied SEM and revealed that both body weight and school performance affect self-esteem. Whereas some researchers who apply SEM would argue that these associations should be interpreted as causal (41-43), epidemiologists would object to such an interpretation, as the observations were cross-sectional (44). Acknowledging these differences in point of view, we recommend

longitudinal studies to confirm the present findings. For example, the present childhood obesity epidemic has urged many jurisdictions to prepare for, or have already implemented, school-based promotion of active living and healthy eating. These initiatives also provide a unique opportunity to prospectively evaluate the importance of active living, healthy eating and body weight for self-esteem and for school performance.

In brief, we have shown that obesity is an important determinant for self-esteem in 10 to 11 year old children. Obesity did not seem to have an independent effect on school performance. However, the established determinants of obesity, poor diet and inactivity, were found to affect both self-esteem and school-performance. In other words, promotion of active living and healthy eating is not only important for the prevention of overweight and related chronic diseases; it may also improve mental health and school performance.

2.5.0 Conclusions

Consequences of obesity for mental health and school performance are not established to the same degree as those for chronic diseases. This study aims to document the interrelationships between body weight, self-esteem and school performance in childhood. Height and weight measurements and self-report of self-esteem, physical activity and diet quality of 4945 grade 5 students were linked with standardized literacy test results. Structural equation models were applied and revealed that body weight affected self-esteem negatively and that school performance affected self-esteem positively. Body weight did not affect school performance, and self-esteem did affect neither body weight nor school performance. Subsequent multilevel logistic regression showed that obese students, relative to normal weight students, were more likely (1.44; 95% CI: 1.12 - 1.84), and students with good school performance, relative to those performing poor, were less likely (0.39; 95% CI: 0.26 - 0.58), to have low self-esteem. Active living and diet quality had positive effects on both school performance and self-esteem. The study findings further establish obesity as a risk factor for low self-esteem and add to the rationale to promote active living and healthy eating among children and youth as this will prevent chronic diseases and improve mental health and school performance.

Table 2-1 Variables and their coding in structural equation models and multilevel regression analysis

		structural equation models	multilevel regression
Body-weight status	BMI from measured height and weight	weight (kg)/height (m^2) (considered continuous)	1=normal weight 2=overweight 3=obesity
School performance	Province test on reading and writing	1=both reading and writing below standard 2=one below, one meets standard 3=both meet standard or one below and one exceeds standard 4=one meets, one exceeds standard 5=both exceed standard	1=below standard (reading and/or writing below standard) 2=meets standard (neither category 1 or 3) 3=exceeds standard (exceed standard of both reading and writing)
Self-esteem	Self-report	Score ranges from 0-33	0=normal self-esteem 1=low self-esteem
Gender	Self-report	1=girl, 2=boy	1=girl, 2=boy
Residence	Parent report	1=rural, 2=urban	1=rural, 2=urban
Household income	Parent report	1=$20,000 or less 2=$20,001-$40,000 3=$40,001-$60,000 4=$60,001 or more	1=$20,000 or less 2=$20,001-$40,000 3=$40,001-$60,000 4=$60,001 or more
Parental education	Parent report	1=secondary or less 2=community college 3=university 4=graduate university	1=secondary or less 2=community college 3=university 4=graduate university
Physical activity	Self-report	1: <= twice/wk 2: >2 and <=4 times/wk 3: >4 and <=7 times/wk 4: >7 times/wk	1: <= twice/wk 2: >2 and <=4 times/wk 3: >4 and <=7 times/wk 4: >7 times/wk
Sedentary activity	Self-report	1: <=1 hour/d 2: >1 and <=3 hr/d 3: >3 and <=6 hr/d 4: >6 hr/d	1: <=1 hour/d 2: >1 and <=3 hr/d 3: >3 and <=6 hr/d 4: >6 hr/d
Diet Quality Index	Calculated from Harvard Food Frequency Questionnaire	Score ranges from 0-100 (considered continuous)	1=1st tertile (lowest) 2=2nd tertile (average) 3=3rd tertile (highest)
School neighborhood level income	Canada census	In thousands of dollars (considered continuous)	1=1st tertile (lowest) 2=2nd tertile (average) 3=3rd tertile (highest) Considered as second level covariate
School-level academic performance	Provincial standard reading and writing test	Percentage of students failing both assessments	1=<10% failure 2=10% -19% failure 3=20% - 29% failure Considered as second level covariate

Note: [a] BMI, body mass index

Table 2-2 Distribution of the characteristics of the CLASS study by different weight groups

Characteristics	Total	Normal weight	Overweight	Obesity	*p*-value*
Participants, *N*	4945 (100.00%)	2715 (66.66)	956 (23.47)	402 (9.87)	
Self-esteem (%)					
Normal	81.76	83.24	80.54	74.63	**0.000**
Low	18.24	16.76	19.46	25.37	
School performance (%)					
Below standard (poor)	18.17	17.26	18.54	23.61	**0.006**
Meets standard (average)	70.33	70.39	70.76	68.89	
Exceeds standard (good)	11.50	12.35	10.69	7.50	
Gender (%)					
Girl	50.75	50.79	52.72	45.27	0.065
Boy	49.25	49.21	47.28	54.23	
Residence (%)					
Rural	39.65	37.35	42.57	48.26	**0.000**
Urban	60.35	62.65	57.43	51.74	
Household income (%)					
< $ 20,000	10.18	9.22	10.66	15.74	**0.000**
$ 20,000 – 39,999	22.01	20.32	23.50	30.16	
$ 40,000 – 59,999	26.32	26.09	26.64	27.21	
≥ $60,000	41.48	44.38	39.21	26.89	
Parental education (%)					
Secondary school or less	29.57	27.30	30.99	41.55	**0.000**
Community college	37.24	36.69	39.50	35.66	
University	23.77	25.55	21.45	17.16	
Graduate university	9.42	10.46	8.06	5.63	
Physical activity (%)					
<= twice/week	12.59	11.61	13.49	17.09	**0.023**
>2 and <=4 times/week	23.40	23.41	24.03	21.86	
>4 and <=7 times/week	53.84	54.04	53.64	53.02	
>7 times/week	10.16	10.94	8.85	8.04	
Sedentary activity (%)					
<=1 hour/day	10.37	11.23	9.25	7.25	0.100
>1 and <=3 hr/day	41.40	41.64	41.66	39.25	
>3 and <=6 hr/day	26.02	25.61	26.14	28.50	
>6 hr/day	22.20	21.52	22.95	25.00	
DQI (%)					
1st tertile (lowest)	31.90	30.50	34.25	35.75	0.113
2nd tertile (average)	32.16	32.62	31.51	30.57	
3rd tertile (highest)	35.94	36.88	34.25	33.68	
School neighborhood average income (%)					
1st tertile (lowest)	26.49	25.75	26.57	31.34	**0.000**
2nd tertile (average)	35.89	34.36	37.45	42.54	
3rd tertile (highest)	37.61	39.89	35.98	26.12	
School level academic performance (%)					
<10% failure	9.33	10.07	8.38	6.65	**0.001**
10%-19% failure	7.61	8.17	7.54	4.05	
20%-29% failure	13.54	14.53	11.14	12.72	
30%-39% failure	69.52	67.23	72.93	76.59	

Note: [a] The data includes 4945 students with available information on self-esteem participating in the Children's Lifestyle and School-performance Study (CLASS).

Table 2-3 Structural coefficients and 95% confidence intervals of exogenous variables with BMI, school performance, and self-esteem

Exogenous Variables	BMI	School Performance	Self-esteem
Gender	0.005 (-0.244, 0.254)	**-0.344 (-0.401, -0.288)**	-0.046 (-0.236, 0.143)
Residence	-0.117 (-0.403, 0.169)	**0.061 (0.004 , 0.126)**	**0.283 (0.089, 0.478)**
Household income	**-0.303 (-0.454,-0.151)**	**0.147 (0.113, 0.182)**	**0.217 (0.107, 0.327)**
Parental education	**-0.429 (-0.582,-0.276)**	**0.145 (0.110, 0.180)**	**0.160 (0.044, 0.276)**
Physical activity	-0.086 (-0.248, 0.075)	-0.012 (-0.048, 0.025)	**0.176 (0.055, 0.298)**
Sedentary activity	-0.010 (-0.150, 0.130)	**-0.040 (-0.072, -0.008)**	**-0.429 (-0.534, -0.324)**
Diet quality index	-0.011 (-0.025, 0.003)	**0.006 (0.003, 0. 009)**	0.009 (-0.002, 0.019)
School neighborhood level income [b]	**-0.013 (-0.024,-0.002)**	-0.001 (-0.004, 0. 002)	—
School-level academic performance [b]	**0.192 (0.059, 0.326)**	-0.103 (-0.133, 0.073)	—

Note: [a] The model had a 1.0000 goodness-of-fit index (GFI) and its comparative GFI was equal to 0.9993. The goodness-of-fit Chi-Square was 0.4455 (d.f.=2; *P*=0.8003). Root Mean Square Error of Approximation (RMSEA) =0.0000.

[b] We did not assume the existence of a direct causal relationship between school neighborhood level income and self-esteem and between school-level academic performance and self-esteem. Models that included these relationships failed the GFI criterion, indicating a poor agreement between hypothesized model and observations.

[c] BMI, body mass index.

[d] For the original output, please refer to Appendix 1.

Table 2-4 Determinants of low self-esteem among grade five students

Risk factors	% of student	Unadjusted Odds Ratio (95% CI[a])	Adjusted Odds Ratio (95% CI[a])
Body weight status			
Normal	66.6	1	1
Overweight	23.5	1.18 (0.98-1.43)	1.17 (0.96-1.42)
Obesity	9.9	**1.72 (1.37-2.16)**	**1.44 (1.12-1.84)**
School performance			
Below standard (poor)	18.2	1	1
Meets standard (average)	70.9	**0.46 (0.39-0.55)**	**0.55 (0.46-0.67)**
Exceeds standard (good)	10.9	**0.25 (0.17-0.39)**	**0.39 (0.26-0.58)**
Gender			
Girl	51.0	1	
Boy	49.0	**1.43 (1.23-1.66)**	
Residence			
Rural	34.5	1	
Urban	65.5	**0.69 (0.57-0.83)**	
Household income			
< $ 20,000	11.2	1	
$ 20,000 – 39,999	22.4	**0.76 (0.59-0.97)**	
$ 40,000 – 59,999	26.3	**0.58 (0.45-0.76)**	
≥ $60,000	40.1	**0.39 (0.30-0.52)**	
Parental education			
Secondary school or less	29.6	1	1
Community college	37.4	**0.78 (0.66-0.93)**	0.86 (0.72-1.04)
University	23.6	**0.49 (0.38-0.63)**	**0.68 (0.52-0.88)**
Graduate university	9.4	**0.39 (0.26-0.60)**	**0.65 (0.44-0.98)**
Physical activity			
<= twice/week	12.3	1	1
>2 and <=4 times/week	22.7	**0.52 (0.40-0.67)**	**0.63 (0.49-0.82)**
>4 and <=7 times/week	54.6	**0.65 (0.53-0.79)**	**0.74 (0.60-0.92)**
>7 times/week	10.4	**0.61 (0.45-0.83)**	0.78 (0.57-1.07)
Sedentary activity			
<=1 hour/day	9.8	1	1
>1 and <=3 hr/day	41.0	0.88 (0.64-1.19)	0.97 (0.70-1.34)
>3 and <=6 hr/day	26.8	1.23 (0.90-1.68)	1.20 (0.86-1.68)
>6 hr/day	22.4	**2.13 (1.16-3.85)**	**1.68 (1.21-2.34)**
DQI [d]			
1st tertile (lowest)		1	1
2nd tertile (average)		**0.53 (0.43-0.66)**	**0.63 (0.51-0.77)**
3rd tertile (highest)		**0.61 (0.51-0.74)**	**0.81 (0.67-0.99)**
School neighborhood level income			
1st tertile (lowest)		1	
2nd tertile (average)		0.99 (0.81-1.20)	
3rd tertile (highest)		**0.73 (0.58-0.91)**	
School level academic performance			
<10% failure	41.09	1	
10%-19% failure	19.31	0.92 (0.67-1.25)	
20%-29% failure	12.76	1.22 (0.87-1.70)	
30%-39% failure	26.84	1.20 (0.91-1.58)	

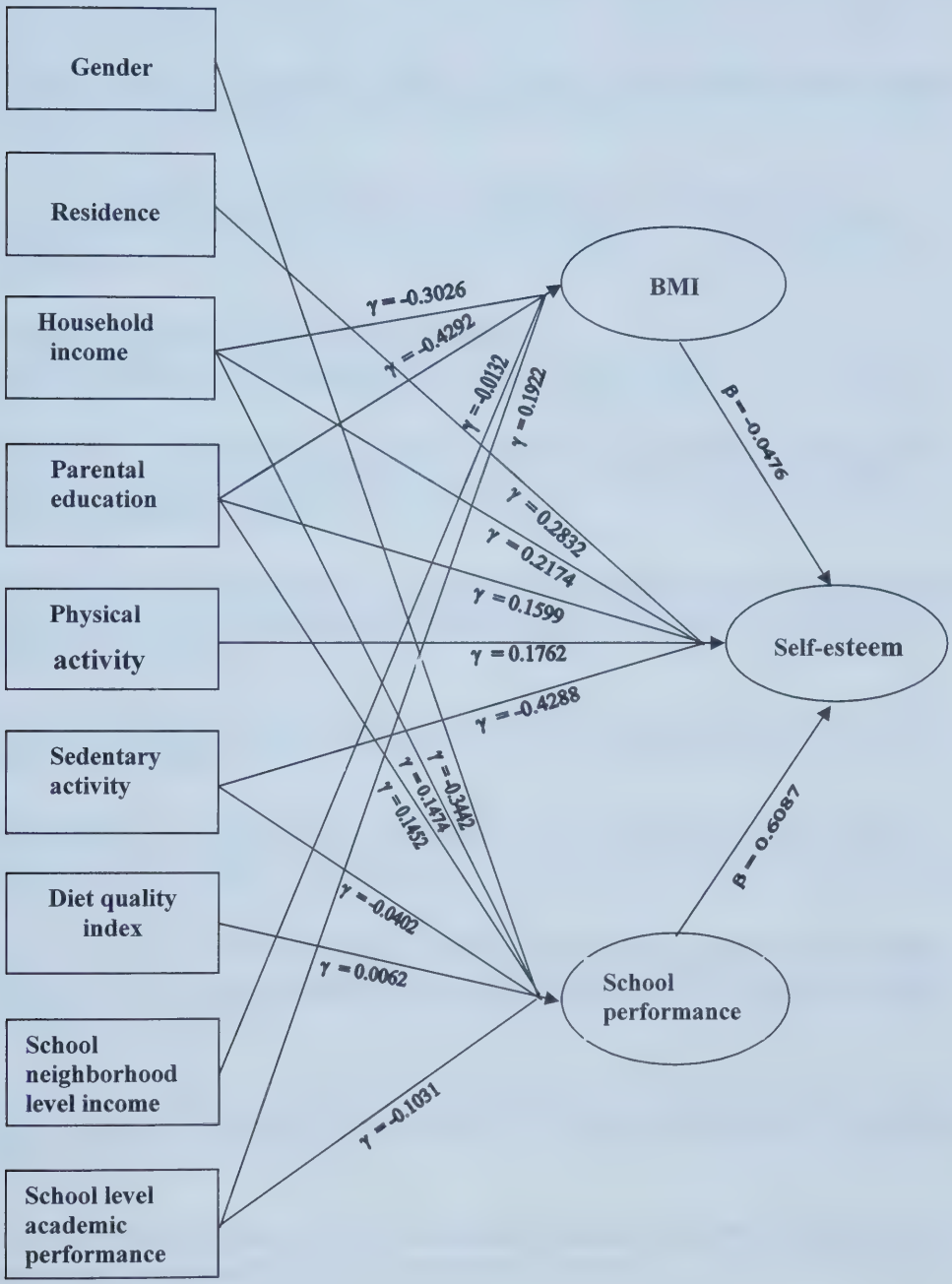
Note: [a] 95% CI: 95% Confidence Interval

[b] Odds ratios are adjusted for energy intake following established recommendations (26).

[c] The findings originate from 4945 students with available information on self-esteem participating in the Children's Lifestyle and School-performance Study.

[d] DQI, Diet Quality Index.

Figure 2-1 Structural coefficients of BMI, school performance, self-esteem and exogenous variables



* γ : Structural coefficient between exogenous and endogenous variables

† β:Structural coefficient between endogenous variables

‡ Only the statistical significant structural coefficients are displayed

§ For the original output, please refer to Appendix 1.

2.6.0 References

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Chapter 3: The Influence of Childhood Obesity on the Development of Self-esteem *

3.1.0 Introduction

Childhood overweight has become pandemic, and prevalence rates continue to rise. While the consequences of overweight in childhood for physical health are well described, (1,2) relatively little research has examined the mental health consequences. (3-5)

Self-esteem is associated with children's social, emotional, behavioral and mental development. (6-10) Several previous studies have reported an inverse relationship between obesity and self-esteem in childhood, (4,11,12) but these studies were cross-sectional and could not establish whether obesity affects self-esteem or whether self-esteem affects obesity. Longitudinal analyses are best suited to disentangle temporal relationships between excess weight and self-esteem, but only two such studies have been published and the findings were mixed. (13,14) One reported that low self-esteem predicted subsequent excess weight among girls, but not among boys. (13) The other concluded that excess weight predicted subsequent low self-esteem, but not vice versa.(14)

This study further investigates longitudinal relationships between excess weight in childhood and low self-esteem, using a large, nationally representative sample of Canadian children. Because the direction of the relationship is not well established, two longitudinal models were examined — one in which childhood overweight precedes the development of low self-esteem (primary research question), and another in which low childhood self-esteem precedes the development of overweight (secondary research question).

3.2.0 Research Design and Methods

3.2.1 Study Design and Sample

* A version of Chapter 3 has been previously published: F.Wang, T.C.Wild, W.Kipp, S.Kuhle and P.J.Veugelers. The influence of childhood obesity on the development of self-esteem. *Health Report* 2009; 20(2):21-27

The data were from Statistics Canada's National Longitudinal Survey of Children and Youth, a prospective cohort survey that described the development, well-being and health of Canadian children and youth. The survey began in 1994/95 (cycle 1) with the enrollment of 22,831 children aged 0 to 11 years. Every two years since then, participants have been re-interviewed. (15) Interviewers administer the survey in person to the child and to the person most knowledgeable about the child (mother: 91.3%; father: 8.2%; non-parent: 0.5%). (15)

The subgroup examined in the present study consists of 2,879 children who were aged 10 or 11 in cycle 1 (only respondents with complete self-esteem measures were included). Follow-up information was available in cycle 2 for 2,018 of these children when they were aged 12 or 13, and for 1,806 of them in cycle 3 when they were aged 14 or 15. Subsequent cycles did not provide comparable information on self-esteem.

3.2.2 Measurement and Evaluation

3.2.2.1 Self-esteem Assessment

Children completed a four-item scale that assessed their overall self-esteem: (1) "In general, I like the way I am"; (2) "Overall I have a lot to be proud of"; (3) "A lot of things about me are good"; and (4) "When I do something, I do it well." Response options for each item were: false, mostly false, sometimes false/sometimes true, mostly true, and true (scored 0, 1, 2, 3 and 4, respectively). Because internal consistency (Cronbach's α) for the composite four-item scale was adequate (0.73), scores were summed. Scores below the 15th percentile on the distribution of scale scores were considered to indicate low self-esteem (this cutoff is a commonly used approximation to the parametric concept of one standard deviation below the mean). (14) Higher scores were considered to indicate normal self-esteem.

3.2.2.2 Weight Assessment

The person most knowledgeable about the child reported the child's height and weight, from which body mass index (kilograms divided by height in meters squared) was calculated. Cutoff points established for children by International Obesity Task Force were applied to determine overweight and obesity. (16) These cutoffs are based on

definitions of adult overweight (body mass index greater than or equal to 25kg/m^2) and obesity (body mass index greater than or equal to 30 kg/m^2), adjusted to specific age and gender categories for children. (16)

3.2.2.3 Covariates

Adjustments were made to account for other variables known to influence the relationship between excess weight and self-esteem: sex of the child, the child's school performance, rural or urban residence, household income, parental education, and the child's physical activity and screen time.(12)

Sex of the child, the child's school performance, rural or urban residence, household income, and parental education were available from a questionnaire completed by the person most knowledgeable about the child. The person most knowledgeable was asked to assess the child's school performance based on their knowledge of his or her schoolwork and report cards: 1) very poor or poor; 2) average; and 3) good or very good. Household income was divided into four categories: lowest (less than $20,000 a year), lower- middle ($20,000 to $39,999), upper-middle ($40,000 to 59,999), and highest ($60,000 or more). Parental education was classified as: 1) less than secondary graduation; 2) secondary graduation; 3) some postsecondary; and 4) postsecondary graduation.

Children answered questions about how frequently they participated in physical activity and screen time. Two physical activity questions were asked: when not at school, whether he or she played any sports or did any physical activities (a) with or (b) without a coach or instructor in the last year. For this analysis, responses to both questions were combined to create four categories: 1) twice a week or less; 2) three or four times a week; 3) five to seven times a week; and 4) eight or more times a week. The two screen time questions, which asked how many times per week (not including school hours) the child (a) used a computer or played video games and (b) watched television, were collapsed into a single indicator.

3.2.3 Data Analysis

3.2.3.1 Distribution and Characteristics of Study Subjects

Descriptive characteristics of 10- and 11-year-old Canadian children in relation to self-esteem (low versus normal) were compared by χ^2 test.

3.2.3.2 The Associations and Relationships between Body Weight and Self-esteem

Because body weight (overweight or obese versus normal weight) and self-esteem (low versus normal) were treated as categorical variables, univariate and multivariate logistic regression analyses were conducted. Cross-sectional data were used to determine concurrent relationships between body weight and self-esteem, based on data from cycle 1 only. To assure valid inferences to the reference population (children aged 10 or 11), these analyses were weighted with National Longitudinal Survey of Children and Youth cross-sectional sampling weights.

The primary research question, "Does excess weight predict low self-esteem at two- and four-year follow-up," was addressed with data on overweight and obesity and potentially confounding covariates obtained at baseline (cycle 1) and follow-up data on self-esteem collected two and four years later (cycles 2 and 3). These analyses were further adjusted for baseline self-esteem to capture the influence of body weight on changes in self-esteem between baseline (cycle 1) and follow-up (cycle 2 or 3).

The secondary research question, "Does self-esteem affect body weight at two- and four-year follow-up," was addressed with information about self- esteem and confounders at baseline (cycle 1) and data on body weight at follow-up (cycles 2 and 3). The analysis also adjusted for baseline (cycle 1) body weight status to capture the influence of self-esteem on changes in body weight between baseline (cycle 1) and follow-up (cycle 2 or 3).

To assure valid inference to the external population, all longitudinal analyses were weighted using relative longitudinal sampling weights. Sampling weights were prepared by Statistics Canada, and accounted for design effects due to complex sampling strategies and for non-response bias. (18) Statistics Canada also provided 1,000 bootstrap weights

for parameter and variance estimation. Missing values were considered as separate covariate categories.

All statistical analyses were performed using the STATA statistical software package, version 10.0.

3.3.0 Results

3.3.1 Low Self-esteem Related to Weight

Descriptive characteristics of 10- and 11-year-old Canadian children in relation to self-esteem (low versus normal) are presented in Table 3-1. Low self-esteem at baseline was more prevalent among overweight and obese children than among their normal-weight contemporaries. Other correlates of low self-esteem were poor school performance, limited parental education, and infrequent physical activity.

3.3.2 Cross-sectional Associations

The results of Table 3-2 present the unadjusted and adjusted cross-sectional associations between body weight and the other variables. Relative to normal-weight children, those who were obese had almost twice the odds of reporting low self-esteem in 1994/1995. This association persisted in multivariate analysis that adjusted for the confounders (OR = 1.84; 95% CI: 1.01 to 3.47). School performance, parental education and physical activity level were also significantly associated with low self-esteem at baseline.

3.3.3 Temporal Relationships

As expected, baseline self-esteem was significantly associated with self-esteem two and four years later (Table 3-3, Table 3-4). Compared to children with normal self-esteem, those whose self-esteem was low at baseline had 3.55 times (95% CI: 2.40 to 5.23) and 3.29 times (95% CI: 2.16 to 5.01) the odds of reporting low self-esteem two and four years later, respectively. Even when baseline self-esteem scores and the other covariates were taken into account, baseline body weight was independently associated with self-esteem in subsequent years (Table 3-3, Table 3-4). Specifically, children who met the

criteria for obesity were significantly more likely than normal-weight children to report low self-esteem four years later (adjusted OR = 1.82; 95% CI: 1.01 to 3.78).

Physical activity and sex were also statistically significant predictors of low self-esteem. Children participating in physical activity five to seven times a week were less likely than those participating no more than twice a week to have low self-esteem four years later (OR=0.55; 95% CI: 0.34 to 0.89). As well, boys were less likely than girls to have low self-esteem four years from baseline (OR=0.37; 95% CI: 0.25 to 0.55).

A complementary multivariate analysis restricted to children with normal self-esteem at baseline showed that the odds of developing low self-esteem four years later were greater (OR=1.36; 95% CI: 0.74 to 2.48) for those who were obese than for those who were in the normal weight range. The difference in this subgroup was not statistically significant.

Ancillary analyses conducted to assess whether self-esteem predicted excess body weight in subsequent years failed to demonstrate a statistically significant relationship. In a multivariate analysis that included all confounding variables in Table 3-1 and adjusted for baseline body weight, the odds of overweight or obesity four years later among children with normal self- esteem at baseline did not differ significantly from the odds for those with low self-esteem at baseline (OR=0.94; 95% CI: 0.40 to 2.22 and OR=0.77; 95% CI: 0.13 to 4.48, respectively).

3.4.0 Discussion

Research on the consequences of childhood obesity has focused primarily on physical health; few studies have examined mental health consequences. Because the findings of earlier studies have been mixed, the goal of this analysis was to examine longitudinal associations between body weight and self-esteem, based on a nationally representative sample of 10- and 11- year-olds.

The cross-sectional results of the present study were similar to those of other cross-sectional analyses, showing that body weight and self-esteem are inversely related among

children. (4,11,12) As well, the longitudinal results are consistent with the view that excess body weight precedes the development of low self-esteem, rather than the reverse.(14) Specifically, even when the effects of a number of variables known to influence self-esteem were taken into account, childhood obesity predicted subsequent low self-esteem, but not vice versa.

These results are important in that other research has shown low self-esteem (negative self-regard) (17) to be associated with subsequent mental health problems such as anxiety, stress, loneliness, and greater likelihood of depression.(6-8) Low self-esteem may also lead to underachievement, increased vulnerability to drug and alcohol abuse, (18,19) and in some cases, self-destructive behavior.(7,10) These mental health issues may be underappreciated consequences of childhood obesity.

Why might obesity be related to the reduction self-esteem? Researchers have suggested that teasing from peers and social stigma could contribute to low self-esteem in obese children. (20-23) In fact, such circumstances may have mediated the longitudinal relationship between body weight and low self-esteem observed in this study, a possibility that might be examined in future research.

Beyond childhood obesity, the results are consistent with studies showing that regular physical activity is positively associated with self-esteem. (24) In particular, children participating in physical activity five to seven times a week reduced their odds of developing low self-esteem four years later by almost half. Thus, promotion of physical activity among all children, regardless of their weight, may enhance self-esteem. Tremblay and colleagues suggest that for some children, physical activity might be related to better academic performance by improving physical health and self-esteem. (25)

The results of studies of sex differences in self-esteem have not been consistent. While some have shown self-esteem to be greater among girls than boys, most have indicated the opposite. (26-28) Others reported no significant gender difference in global self-esteem among children, and the self-esteem of girls to be at least as high as that of

boys.(28,29) The present study found that, relative to girls, boys were significantly less likely to have low self-esteem at ages 10 and 11, and that this difference persisted longitudinally over the four-year follow-up period. Similar differences were reported in other research showing that girls generally assess their physical appearance and athletic competence more negatively than do boys. (30)

Like earlier research, (31,32) this analysis revealed a cross-sectional association between self-esteem and school performance. One mechanism that has been suggested to account for the relationship is that school performance may be enhanced by high self-esteem, since it may raise children's aspirations and foster confidence to deal with problems. (31) Alternatively, children and youth may develop confidence and self-esteem as they do well in school.(12,31,32) Although the current study reconfirms that poor school performance is significantly associated with low self-esteem, it did not predict low self-esteem two and four years later. These observations suggest that poor school performance affects the current level of self-esteem, but not changes of self-esteem over time.

The strengths of the present study include a nationally representative sample of Canadian children and a longitudinal design that made it possible to investigate temporal relationships between body weight and self-esteem. The analyses adjusted for the influence of potential confounders. All analyses were weighted using population sampling weights and bootstrapping weights, which accounted for complex survey design effects and non-response bias, and consequently, enabled the calculation of accurate estimates of standard errors.

Inferences drawn from this study should be tempered by awareness that the data are self-reported, and therefore, subject to error and recall bias. Nutrition and dietary patterns could not be considered because they were not collected in the survey. Such information may be important for future research, given other findings showing that healthy eating is positively associated with school performance (32,33) and self-esteem among children.(12) Body mass index cutoff points established for children by the International

Obesity Task Force were applied to the survey data. These cutoffs do not allow the identification of those who were underweight. Caution is therefore warranted in extrapolating the findings to underweight children.

A final potential limitation is bias stemming from differential loss to follow-up. However, an attrition analysis did not show differential loss to follow-up according to self-esteem and body weight status: relative to children with normal self-esteem at baseline, those whose self-esteem was low had 1.04 times the odds of loss to follow-up at cycle 2; relative to children with normal weight at baseline, those who were overweight had 0.99 times the odds of loss to follow-up at cycle 3.

3.5.0 Conclusions

Most studies of the mental health consequences of childhood obesity, and the few longitudinal studies that have been conducted, could not establish whether excess weight affects self-esteem or whether self-esteem influences excess weight. Results from the current study show that excess body weight predicted the development of low self-esteem among children over a four-year period. Low self-esteem did not predict excess weight. Regular physical activity was positively associated with self-esteem. To summery, with data from the National Longitudinal Survey of Children and Youth, this study replicates and expands previous research showing that obese children are at increased risk of low self-esteem. The downstream consequences may be important, given that other studies have shown low self-esteem to be associated with poor mental health later in life. Interventions designed to promote active living and healthy eating may be beneficial for preventing obesity and improving self-esteem in the short-term, and for preventing chronic diseases and improving mental health in adulthood.

Table 3-1 Percentage distribution of baseline characteristics, household population aged 10 or 11, Canada excluding territories, 1994/1995

	Total	Low self-esteem	Normal self-esteem	*p*-value
		Percentage	distribution	
Body weight				
Normal weight	74.57	68.41	76.01	**0.03**
Overweight	19.69	**22.73**	18.97	
Obesity	5.74	**8.86**	5.01	
School performance				
Poor or very poor	3.49	**5.80**	2.93	**<0.01**
Average	22.99	**29.38**	21.46	
Good or very good	73.52	64.82	75.61	
Sex				
Girl	49.68	50.85	49.40	0.68
Boy	50.32	49.15	50.60	
Residence				
Urban	80.65	80.32	80.73	0.84
Rural	19.35	19.68	19.27	
Annual household income				
Less than $ 20,000	6.10	5.88	6.15	0.87
$ 20,000 – 39,999	19.31	21.23	18.89	
$ 40,000 – 59,999	31.23	31.54	31.16	
$ 60,000 or more	43.36	41.36	43.80	
Parental education				
Less than secondary graduation	6.75	**9.34**	6.24	**0.01**
Secondary graduation	12.38	9.88	13.38	
Some postsecondary	24.85	23.71	25.90	
Postsecondary graduation	56.02	57.07	54.48	
Weekly physical activity				
1= Twice or less	33.77	**39.58**	32.36	**0.03**
2= Three or four times	26.19	25.41	26.38	
3= Five to seven times	34.01	31.96	34.51	
4= Eight or more times	6.03	3.05	6.75	
Weekly screen time				
1= Twice or less	4.52	3.57	4.74	0.85
2= Three or four times	8.21	8.37	8.17	
3= Five to seven times	57.58	57.08	57.70	
4= Eight or more times	29.69	30.98	29.38	

Note: All percentages were weighted sampling weight to represent population estimates. P-values were obtained with x^2 test.
Source: 1994/1995 National Longitudinal Survey of Children and Youth

Table 3-2 Cross-sectional associations between low self-esteem and the other variables

Characteristics in 1994/1995	Univariate [a] Odds Ratio (95% CI)	Multivariate [b] Odds Ratio (95% CI)	Parsimonious [c] Odds Ratio (95% CI)
Body weight status			
Normal	1.00	1.00	1.00
Overweight	1.33 (0.92-1.93)	1.29 (0.86-1.94)	1.32 (0.89-1.96)
Obesity	**1.96 (1.09-3.62)**	**1.84 (1.01-3.47)**	**1.90 (1.01-3.54)**
School performance			
Poor or very poor	1.00	1.00	1.00
Average	0.69 (0.34-1.40)	0.68 (0.33-1.42)	0.67 (0.33-1.36)
Good or very good	**0.43 (0.22-0.84)**	**0.43 (0.21-0.68)**	**0.42 (0.22-0.83)**
Sex			
Girl	1.00	1.00	
Boy	0.94 (0.71-1.26)	0.94 (0.68-1.29)	
Residence			
Rural	1.00	1.00	
Urban	1.03 (0.79-1.34)	1.04 (0.78-1.39)	
Annual household income			
Less than $20,000	1.00	1.00	
$20,000 to $39,999	1.17 (0.52-2.69)	1.27 (0.54-2.99)	
$40,000 to $59,999	1.06 (0.46-2.44)	1.09 (0.46-2.59)	
$60,000 to more	0.99 (0.44-2.20)	1.02 (0.44-2.39)	
Parental education			
Less than secondary graduation	1.00	1.00	1.00
Secondary graduation	**0.41 (0.20-0.84)**	**0.42 (0.19-0.93)**	**0.41 (0.20-0.86)**
Some postsecondary	0.54 (0.28-1.02)	0.58 (0.29-1.16)	0.57 (0.29-1.10)
Postsecondary graduation	0.79 (0.45-1.42)	0.93 (0.48-1.80)	0.88 (0.49-1.59)
Weekly physical activity			
1= Twice or less	1.00	1.00	1.00
2= Three or four times	0.79 (0.54-1.15)	0.83 (0.56-1.23)	0.82 (0.56-1.21)
3= Five to seven times	0.76 (0.54-1.06)	0.79 (0.55-1.12)	0.76 (0.54-1.07)
4= Eight or more times	**0.37 (0.19-0.72)**	**0.37 (0.18-0.77)**	**0.36 (0.18-0.72)**
Weekly screen time			
1= Twice or less	1.00	1.00	
2= Three or four times	1.36 (0.52-3.54)	1.60 (0.60-4.31)	
3= Five to seven times	1.31 (0.58-2.99)	1.33 (0.56-3.16)	
4= Eight or more times	1.40 (0.60-3.24)	1.40 (0.58-3.35)	

Note: [a] In the univariate analyses, each variable was included one at a time in the model.
[b] In the multivariate analyses, all variables were included in the model.
[c] Only significant variables were included in the parsimonious model.
[d] Odds Ratio and 95% CI (95% Confidence Interval) were estimated using 1000 bootstrap cross-sectional weight at Cycle 1 (1994/1995).
[e] The findings originate from 2879 students with available information on self-esteem participating in 1994/1995 National Longitudinal Survey of Children and Youth in Canada.

Table 3-3 Two-year follow-up (1996/1997) temporal relationships between low self-esteem in 1996/1997 and the other variables in 1994/1995

Characteristics in 1994/1995	Univariate [a] Odds Ratio (95% CI)	Multivariate [b] Odds Ratio (95% CI)	Parsimonious [c] Odds Ratio (95% CI)
Self-esteem			
Normal	1.00	1.00	1.00
Low	**3.55 (2.40-5.32)**	**3.40 (2.24-5.17)**	**3.63 (2.47-5.36)**
Body weight status			
Normal	1.00	1.00	
Overweight	1.38 (0.93-2.06)	1.36 (0.87-2.14)	
Obesity	1.47 (0.78-2.57)	1.15 (0.59-2.26)	
School performance			
Poor or very poor	1.00	1.00	
Average	0.72 (0.30-1.73)	0.81 (0.33-2.00)	
Good or very good	**0.41 (0.18-0.97)**	0.47 (0.19-1.13)	
Sex			
Girl	1.00	1.00	1.00
Boy	**0.52 (0.38-0.71)**	**0.48 (0.33-0.69)**	**0.51 (0.37-0.71)**
Residence			
Rural	1.00	1.00	
Urban	1.11 (0.83-1.49)	1.08 (0.79-1.50)	
Annual household income			
Less than $20,000	1.00	1.00	
$20,000 to $39,999	0.60 (0.27-1.35)	0.57 (0.26-1.26)	
$40,000 to $59,999	0.81 (0.36-1.83)	0.80 (0.36-1.76)	
$60,000 to more	0.53 (0.24-1.17)	0.54 (0.24-1.21)	
Parental education			
Less than secondary graduation	1.00	1.00	
Secondary graduation	0.68 (0.36-1.32)	0.81 (0.42-1.57)	
Some postsecondary	0.67 (0.36-1.24)	0.82 (0.45-1.51)	
Postsecondary graduation	0.82 (0.46-1.46)	1.01 (0.55-1.85)	
Weekly physical activity			
1= Twice or less	1.00	1.00	
2= Three or four times	0.66 (0.42-1.04)	0.74 (0.46-1.21)	
3= Five to seven times	**0.68 (0.48-0.98)**	0.79 (0.53-1.19)	
4= Eight or more times	**0.32 (0.15-0.69)**	0.50 (0.22-1.10)	
Weekly screen time			
1= Twice or less	1.00	1.00	
2= Three or four times	0.58 (0.19-1.83)	0.70 (0.21-2.32)	
3= Five to seven times	1.20 (0.45-3.19)	1.23 (0.44-3.42)	
4= Eight or more times	1.27 (0.47-3.47)	1.47 (0.52-4.18)	

Note: [a] In the univariate analyses, each variable was included one at a time in the model.
[b] In the multivariate analyses, all variables were included in the model.
[c] Only significant variables were included in the parsimonious model.
[d] Odds Ratio and 95% CI (95% Confidence Interval) were estimated using 1000 bootstrap two-year follow-up weight at Cycle 2 (1996/1997).
[e] The findings originate from 2018 students with available information on self-esteem participating in 1996/1997 National Longitudinal Survey of Children and Youth in Canada.

Table 3.4 Four-year follow up (1998/1999) temporal relationships between low self esteem in 1998/1999 and the other variables in 1994/1995

Characteristics in 1994/1995	Univariate[a] Odds Ratio (95% CI)	Multivariate[b] Odds Ratio (95% CI)	Parsimonious[c] Odds Ratio (95% CI)
Self-esteem			
Normal	1.00	1.00	1.00
Low	**3.29 (2.16-5.01)**	**3.19 (1.97-5.17)**	**4.17 (1.99-8.04)**
Body weight status			
Normal	1.00	1.00	1.00
Overweight	1.17 (0.74-1.85)	1.03 (0.64-1.66)	1.09 (0.70-1.69)
Obesity	**2.18 (1.06-4.49)**	**1.87 (1.01-3.78)**	**2.04 (1.04-3.97)**
School performance			
Poor or very poor	1.00	1.00	
Average	1.76 (0.91-3.43)	1.45 (0.74-2.82)	
Good or very good	1.41 (0.72-2.78)	1.20 (0.61-2.37)	
Sex			
Girl	1.00	1.00	1.00
Boy	**0.35 (0.23-0.54)**	**0.37 (0.25-0.55)**	**0.35 (0.23-0.55)**
Residence			
Rural	1.00	1.00	
Urban	1.30 (0.93-1.82)	1.18 (0.83-1.71)	
Annual household income			
Less than $20,000	1.00	1.00	
$20,000 to $39,999	1.28 (0.86-1.89)	0.91 (0.58-1.41)	
$40,000 to $59,999	1.30 (0.81-2.08)	0.96 (0.61-1.51)	
$60,000 to more	0.82 (0.48-1.38)	0.65 (0.38-1.11)	
Parental education			
Less than secondary graduation	1.00	1.00	
Secondary graduation	0.86 (0.49-1.48)	0.98 (0.55-1.73)	
Some postsecondary	0.93 (0.47-1.81)	1.16 (0.57-2.35)	
Postsecondary graduation	1.06 (0.55-1.97)	1.24 (0.63-2.42)	
Weekly physical activity			
1- Once or less	1.00	1.00	
2- Two or four times	0.73 (0.45-1.17)	0.77 (0.47-1.26)	
3- Five to seven times	**0.50 (0.30-0.76)**	**0.52 (0.34-0.80)**	
4- Eight or more times	0.63 (0.38-1.03)	0.67 (0.41-1.09)	
Weekly screen time			
1- Once or less	1.00	1.00	
2- Two or four times	0.83 (0.47-1.44)	0.81 (0.45-1.45)	
3- Five to seven times	1.50 (0.89-2.52)	1.45 (0.85-2.47)	
4- Eight or more times	1.87 (1.12-3.11)	2.04 (1.19-3.50)	

Notes: [a] In the univariate analyses, each variable was included one at a time in the model.
[b] In the multivariate analyses, all variables were included in the model.
[c] Only significant variables were included in the parsimonious model.
Odds Ratio and 95% CI (95% Confidence Interval) were estimated using 1998 Canadian National Population Health Survey longitudinal sample of Quebec's (1998/1999).
[d] The findings of grade four (4th) students with regular attendance at an English primary school in 1998, 1999 National Longitudinal Survey of Children and Youth of Canada

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Chapter 4: The Directions and Underlying Mechanisms of the Associations between Body Mass Index, School Performance and Self-esteem

4.1.0 Introduction

As the epidemic of childhood overweight and obesity continues to grow in industrial countries, (1-3) evidence-based research should be done under the pressure of the necessity for developing intervention plans. With the aim of getting new evidence, our previous study with CLASS data (Chapter 2) has studied children overweight, school performance and self-esteem simultaneously, reported the directions of the associations between childhood body mass index (BMI), school performance and self-esteem, and revealed the determinants for low self-esteem. (4) The findings are unique in establishing consequences of obesity for mental health, specifically self-esteem, and school performance.

As conclusions from one study could be limited, the main purpose of the current study is to reconfirm the directionality of the associations between childhood body mass index, school performance and self-esteem by using a different school population survey data, the baseline data of National Longitudinal Survey of Children and Youth (NLSCY) in Canada, to compare the result of a provincial children sample in Nova Scotia with that of a nationally representative sample of Canadian children, and further, to explain the underlying mechanisms of the associations demonstrating how body mass index and school performance associated with self-esteem.

4.2.0 Research Design and Methods

4.2.1 Study Design

The data were from Statistics Canada's National Longitudinal Survey of Children and Youth, a prospective cohort survey that described the development, well-being and health of Canadian children and youth. The survey began in 1994/95 (cycle 1) with the enrollment of 22,831 children aged 0 to 11 years. Every two years since then, participants have been re-interviewed. Interviewers administered the survey in person or by phone to

the child and to the person most knowledgeable about the child. 91.3% were the mothers, 8.2% were the fathers and 0.5% was other persons. (5)

4.2.2 Sample

This study targeted a sub-group of 2,879 children who were aged 10 or 11 in cycle 1. Only these children completed a self-esteem questionnaire. The weighted prevalence estimates of socio-demographic and other characteristics of participants included in the study were presented in Table 4-1.

Ethics Approval

Statistics Canada gave consent for this study to be performed using confidential micro data from the National Longitudinal Survey of Children and Youth (NLSCY).

4.2.3 Measurement and Evaluation

4.2.3.1 Self-esteem

Children completed a four-item scale that assessed their overall self-esteem: (i) "In general, I like the way I am"; (ii)"Overall I have a lot to be proud of"; (iii)"A lot of things about me are good"; and (iv)"When I do something, I do it well." Response options for each item were: false, mostly false, sometimes false/sometimes true, mostly true, and true. We scored these responses as 0, 1, 2, 3 and 4, with the highest score representing good self-esteem, and subsequently totaled the scores. The self-esteem score therefore ranged from 0 to 16. The inter-item reliability (Cronbach's alpha) of the 4 items was 0.73, which indicated sufficient internal consistency of the self-esteem questionnaire.

4.2.3.2 Body Mass Index

The person most knowledgeable about the child reported the child's height and weight, from which body mass index was calculated.

4.2.3.3 School Performance

The person most knowledgeable was asked to assess the child's school performance based on their knowledge of his or her schoolwork and report cards: (i) very poor; (ii) poor; (iii) average; (iv) good; and (v) very good.

4.2.3.4 Other Independent Variables

Adjustments were made to account for other independent variables known to influence the relationship between BMI, school performance and self-esteem: gender of the child, rural or urban residence, household income, parental education, and the child's physical activity and screen time involving using a computer, playing video games and watching television.

Gender of the child, rural or urban residence, household income, and parental education were available from a questionnaire completed by the person most knowledgeable about the child. Household income was divided into four categories: lowest (less than $20,000 a year), lower- middle ($20,000 to $39,999), upper-middle ($40,000 to 59,999), and highest ($60,000 or more). Parental education was classified as: (i) less than secondary graduation; (ii) secondary graduation; (iii) some postsecondary; and (iv) postsecondary graduation.

Children also answered questions about how frequently they participated in physical activity and TV/computer screen time. Two physical activity questions were asked: when not at school, whether he or she played any sports or did any physical activities (a) with or (b) without a coach or instructor in the last year. For this analysis, responses to both questions were categorized as follows: (i) twice a week or less; (ii) three or four times a week; (iii) five to seven times a week; and (iv) eight or more times a week. Regarding screen time two questions were asked: How many times per week (not including school hours) the child (a) used a computer or played video games and (b) watched television. Responses to both questions were included in one single indicator.

4.2.4 Data Analysis

Structural equation modeling (SEM) is a statistical technique for testing and estimating the directionality of the associations using a combination of statistical data. (6) In comparison to regression analysis, structural equation modeling can analyze two or more dependent variables simultaneously, consider both direct and indirect effects among dependent variables and independent variables, and a

variable can play a double role in a model (both independent and dependent). (7-9) Using this technique, we were able to assess the directions and underlying mechanisms of the associations between body mass index, school performance and self-esteem simultaneously.

Like analysis of CLASS data (Chapter 2), body mass index, school performance and self-esteem were considered as dependent variables that were endogenous concepts. All other variables were considered as independent variables (exogenous concepts) including child's gender, rural or urban residency, household income, parental education, child's physical activity and screen time.

We started with trying to build a model based on the hypothesis that included each of the six relational combinations (i) body weight affects self-esteem; (ii) self-esteem affects body weight; (iii) body weight affects school performance; (iv) school performance affects body weight; (v) school performance affects self-esteem and (vi) self-esteem affects school performance. Often the initial hypothesis requires adjustment in light of model evidence. (9) Upon failure to confirm our initial hypothesized model above, i.e. when the goodness-of-fit χ^2 test statistic revealed a statistically significant difference between the hypothesized model and the observations, we reduced the number of relational combinations by removing the relational combination with the poorest fit. Subsequently, we tried to confirm the modified hypothesis with reduced model. We repeated this process until we confirmed the existence of a model with a satisfactory goodness of fit ($P > 0.05$). In the above models, we considered the confounding influence of child's gender, rural or urban residency, household income, parental education, child's physical activity and screen time (the exogenous concepts) on body weight, school performance and self-esteem. BMI was considered as a continuous concept of body weight, self-esteem score as a continuous concept and school performance as an ordinal concept of five categories. Details of variables and their coding in cross-sectional SEM are provided in Table 4-2. Unstandardized structural coefficients are reported in the current study.

In order to assure valid inferences to the target population, our analyses were weighted by using baseline cross-sectional sampling weights. Sampling weights were prepared by Statistics Canada, and took into account both design effects inherent in the complex survey design, as well as non-response bias.

Pairwise missing was used in structural equation models that were constructed by using LISREL, version 8.0.

4.3.0 Results

4.3.1 Directions of the Associations

Results of current structural equation model reconfirmed our previous study with CLASS data demonstrating the existence of three causal links among the three endogenous concepts, two of which were statistically significant. (i) Body weight affected self-esteem whereby an increase of one unit of BMI was associated with a decrease of 0.055 (95% confidence interval [CI]: -0.069, -0.041) in self-esteem score. (ii) School performance affected self-esteem whereby an increase of one unit of school performance was associated with an increase of 0.442 (95% CI: 0.390, 0.494) in self-esteem score. (iii) The effect of body weight on school performance was not statistically significant ($\beta = 0.005$; 95% CI: -0.011, 0.001). Self-esteem neither affected BMI nor school performance. And school performance did not affect BMI.

The structural coefficients (and 95% CIs) of the exogenous concepts with each of the three endogenous concepts are shown in Table 4-3. Figure 4-1 displays those statistically significant structural coefficients of exogenous concepts with endogenous concepts (γ's) and those structural coefficients between endogenous concepts (β's). Appendix 2 shows the original output of Figure 4-1.

Child's gender affected BMI in a positive manner and affected school performance in a negative manner, which indicated that the BMI of boys was significantly higher than that of girls and that their school performance was significantly poorer than that of girls. Family residence affected BMI in a positive manner indicating BMI of urban children

was significantly higher than that of children living in rural. Socioeconomic factors, both household income and parental education, affected school performance in a statistically significant manner. Parent education also affected self-esteem in a positive manner. Physical activity affected BMI in a negative manner and affected self-esteem in a positive manner. In contrast, screen time affected BMI in a positive manner and affected both self-esteem and school performance in a negative manner. The goodness-of-fit χ^2 test statistic (Table 4-3, P = 0.5956) showed that the obtained model provided a good representation of the observations.

4.3.2 Underlying Mechanisms of the Associations

Underlying mechanisms of the significant associations in the above model were displayed in Figure 4-1 and could be described as follows: Body mass index had a direct negative effect on self-esteem of magnitude -0.055, and school performance had a direct positive effect on self-esteem of magnitude 0.442. Gender had two indirect effects on self-esteem, one via body mass index was estimated at -0.022=0.407×-0.055 and another one via school performance at -0.104=-0.236×0.442, giving the total net effect a negative estimate of -0.126. The model also estimated an indirect (via body mass index) effect of residence on self-esteem at -0.022=0.391×-0.055. Household income, on the other hand, had only an indirect positive effect on self-esteem via school performance and was estimated at 0.027=0.062×0.442. A direct effect of parental education on self-esteem was estimated at 0.135, while that of the indirect effect via school performance at 0.028=0.063×0.442, giving the total net effect a positive estimate of 0.163=0.135+0.028. The direct, indirect (via body mass index) and total effects of physical activity on self-esteem were estimated at 0.260, 0.011=-0.194×-0.055, and 0.271=0.260+0.011, respectively. A direct effect of screen time on self-esteem was estimated at -0.151, while that of the two indirect effects one via body mass index at -0.021=0.376×-0.055 and another one mediated through school performance at -0.022=-0.050×0.442, giving the total effects a negative estimate of -0.194.

4.4.0 Discussion

The findings of the current study was in agreement with our earlier study findings with the CLASS data showing that both childhood body weight and school performance affected self-esteem but that no other statistically significant associations between the three endogenous concepts existed. (4) As the findings of the NLSCY study supported our previous study with the CLASS data, we concluded that both excess body weight and poor school performance had a negative association with self-esteem. In other words, the findings were supported by two population-based studies and the conclusions were the same in a Canadian nationally representative sample as in Nova Scotia provincial sample of children.

Overweight and obese children are more likely to have a lower self-esteem. In western countries, people usually hold a negative attitude toward overweight and obese individuals across age and gender because there is a culture stereotype that 'fat is bad'. (10) Negative attitudes about overweight and obesity even are present in children as young as 3 years of age. (11) Some researchers indicated that teasing about overweight from peers or family members was consistently associated with low self-esteem, even after controlling for actual body weight.(10,12) Body size stigmatization and teasing could result in victimization of children with overweight and obese, which in turn can significantly reduce or destroy their self-esteem. (13-15) As the inverse relation is stronger for people who perceive themselves as overweight than for people who actually are overweight, interventions should focus to change such negative beliefs by many overweight and obese children so as to improve their self-esteem.

Most studies have found that self-esteem is positively correlated with academic or school performance.(16-18) After summarizing the findings of 12 cross sectional studies and 6 follow up studies, Baumeister and his colleagues concluded that self-esteem is a result, not a cause, of doing well in academic or school performance. (17) At the same time, self-esteem has a very weak or no impact on subsequent academic or school performance. (16) Our study reconfirmed that as school performance improved, child's self-esteem increased, which not only was consistent with many previous studies and our previous

study using the CLASS data, but suggested that childhood self-esteem rises and falls in response to school successes and failures.

Findings from our present study provided further justification that more physical activity and less screen time not only resulted in reducing body weight, but directly and indirectly via reduced body weight promoted positive self-esteem, which added more evidence of the importance of an active lifestyle reducing childhood overweight and obesity, as well as promoting mental health, including self-esteem. The previous research has reported that physical exercise may have short term beneficial effects on self-esteem in children. (19) However, few studies have reported the longer term effect of physical activity on self-esteem in children, and to the best of our knowledge, no research has involved measuring screen time, therefore we suggest a longitudinal study to further confirm the present findings.

Research has identified that there were some significant effects of parental education, occupation, income, parenting styles and parental marital status on self-esteem of children. (20-25) The strong relationship between higher self-esteem and higher social class was found. (21) Lower social class, economic hardship and neighborhood unemployment had adverse effects on the self-esteem of children and adolescent. (20-23) Adolescent boys with a single parent are at risk for developing low self-esteem. (24) Researchers reviewed and summarized a list of parental factors which had been found to foster high self-esteem in children, including parental involvement, parental warmth relationship with child and consistency, respect for children, clear expectation and role modeling, etc.(25-27) The current study found that as parental education increased, child's self-esteem could be directly and indirectly increased that supported previous reports.

Both our current NLSCY study and previous CLASS study were population-based surveys with larger sample of Canadian children who were primarily 10 or 11 years old. One of the strengths of the NLSCY study was that all analyses were weighted by using population sampling weights that accounted for complex survey design and non-response

bias. However, all data in the NLSCY were collected by self-report and self-esteem questionnaire only included 4 items, especially body mass index was assessed using a calculation of parent-reported measures with limited reliability and validity, and school performance of child was evaluated by parent subject to recall bias and error. The CLASS study compensated for these limitations, specifically child's height and weight were measured during the survey by the trained CLASS representatives, self-esteem questionnaire included 11 items and school performance was tested by using a standard test, which strengthened the study findings. We noticed that findings from both studies were only applicable to children aged 10 or 11 years. As a result, the study observations should be cautiously generalized to the general population of children. Finally we suggest additional longitudinal studies to further confirm our present findings.

4.5.0 Conclusions

This study was designed to reconfirm the directions and reveal the underlying mechanisms of the associations between body mass index, school performance and self-esteem in a sample of Canadian nationally representative children sample who were primarily 10 or 11 years old. Results of the study were in agreement with our previous observations in Nova Scotia (CLASS), in spite of difference in measurements of body weight, self-esteem and school performance. The findings consistently demonstrated that excess body weight and poor school performance were significantly associated with low self-esteem. The study further highlighted the necessity of promoting an active lifestyle among children as a method of reducing body weight, as well as fostering a positive self-esteem. It also provided justification for emphasizing the priority of improving self-esteem for children with socioeconomic disadvantaged families.

Table 4-1 Baseline Weighted Prevalence Estimates of Socio-demographic and Other Characteristics of Participants in Structural Equation Model

Independent Variable	Cross-sectional SEM
Participants, *N*	2879 (100.00%)
Gender (%)	
Girl	49.68
Boy	50.32
Residence (%)	
Urban	80.65
Rural	19.35
Household income (%)	
< $ 20,000	6.10
$ 20,000 – 39,999	19.31
$ 40,000 – 59,999	31.23
≥ $60,000	43.36
Parental education (%)	
Less than secondary graduation	6.75
Secondary graduation	12.38
Some postsecondary	24.85
Postsecondary graduation	56.02
Weekly physical activity (%)	
Twice or less	33.77
Three or four times	26.19
Five to seven times	34.01
Eight or more times	6.03
Weekly screen time (%)	
Twice or less	5.52
Three or four times	8.21
Five to seven times	56.58
Eight or more times	29.69
BMI (%)	
School performance (%)	
Poor or very poor	
Average	
Good or very good	
Self-esteem score (%)	

Note: [a] SEM: Structural Equation Model

[b] The data includes children with available information on self-esteem in Cycle 1 (1994/1995) participating in the Canadian National Longitudinal Survey of Children and Youth (NLSCY).

Table 4-2 Variables and their coding in cross-sectional structural equation model

Variables		Cross-sectional model
Body mass index	BMI from PMK reported height and weight	weight (kg)/height (m^2) (considered continuous)
School performance	Reported by PMK	1=Very poor 2=Poor 3=Average 4=Good 5=Very good
Self-esteem	Student report	Score ranges from 0 to 16 (considered continuous)
Gender	PMK report	1=Girl, 2=Boy
Residence	PMK report	1=Urban, 2=Rural
Annual household income	PMK report	1=Less than $20,000 2=$20,000 to $39,999 3=$40,000 to $59,999 4=$60,000 or more
Parental education	PMK report	1= Less than secondary graduation 2= Secondary graduation 3= Some postsecondary 4= Postsecondary graduation
Weekly physical activity	Student report	1= Twice or less 2= Three or four times 3= Five to seven times 4= Eight or more times
Weekly screen time	Student report	1= Twice or less 2= Three or four times 3= Five to seven times 4= Eight or more times

Note: BMI, Body Mass Index
PMK, the Person Most Knowledgeable about the child

Table 4-3 Cross-sectional structural coefficients and 95% confidence intervals of exogenous variables with BMI, school performance, and self-esteem

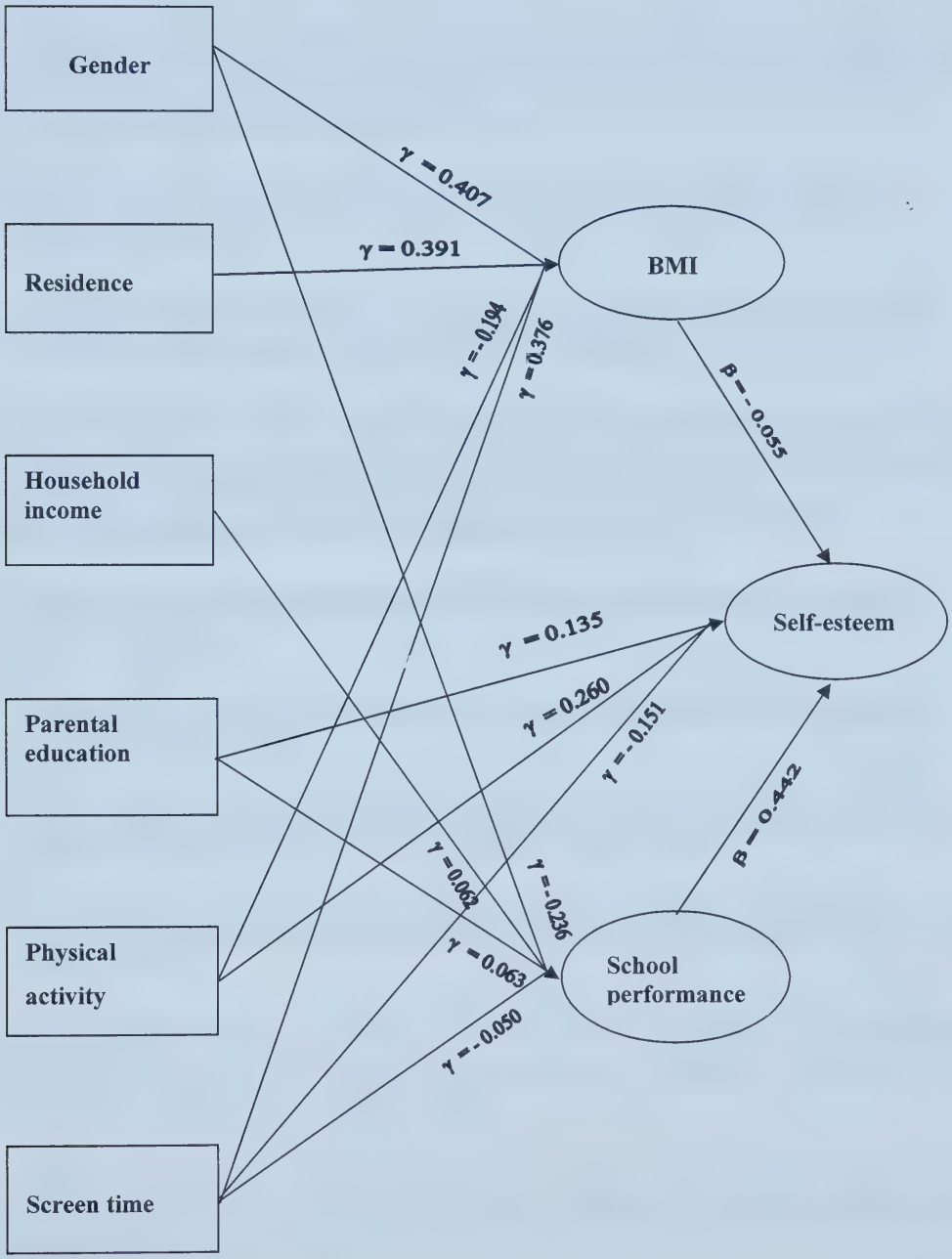
Exogenous Variables	BMI	School Performance	Self-esteem
Gender	**0.407 (0.277, 0.594)**	**-0.236 (-0.271, -0.201)**	0.117 (-0.024, 0.210)
Residence	**0.391 (0.230, 0.552)**	0.030 (-0.013 , 0.074)	0.003 (-0.112, 0.118)
Household income	- 0.008 (-0.084, 0.067)	**0.062 (0.039, 0.086)**	0.039 (-0.015, 0.092)
Parental education	- 0.046 (-0.121, 0.029)	**0.063 (0.050, 0.074)**	**0.135 (0.081, 0.188)**
Physical activity	**- 0.194 (-0.264,-0.123)**	0.024 (-0.005, 0.043)	**0.260 (0.210, 0.310)**
Screen time	**0.376 (0.286, 0.465)**	**-0.050 (-0.074, -0.025)**	**-0.151 (-0.087, -0.215)**

Note: [a] The model had a 1.0000 goodness-of-fit index (GFI) and its comparative GFI was equal to 0.9999. The goodness-of-fit Chi-Square was 0.2817 (d.f.=1; P=0.5956). Root Mean Square Error of Approximation (RMSEA) =0.0000.

[b] BMI, body mass index.

[d] For the original output, please refer to Appendix 2.

Figure 4-1 Cross-sectional structural coefficients of BMI, school performance, self-esteem and exogenous variables



* γ : Structural coefficient between exogenous and endogenous variables

† β : Structural coefficient between endogenous variables

‡ Only the statistical significant structural coefficients are displayed

§ For the original output, please refer to Appendix 2.

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Chapter 5: The Longitudinal Impacts and Underlying Mechanisms of Changes in 2-year Late Body Mass Index and School Performance on 4-year Late Self-esteem

5.1.0 Introduction

Childhood overweight and obesity has become a global epidemic affecting children of all ages and ethnic and socioeconomic backgrounds. (1-3) In order to give new evidence to mental health consequence of childhood overweight and obesity and to be able to institute more effective interventions, our three previous studies have studied body weight, school performance and self-esteem simultaneously, clarified the directions of the associations between body mass index, school performance and self-esteem (Chapter 2 and Chapter 4), and reported the cross-sectional associations (Chapter 2 and Chapter 3) and temporal relationships (Chapter 3) between childhood overweight, school performance and self-esteem. (4,5) The findings further established obesity and poor school performance were important determinants for low self-esteem (4) and demonstrated that childhood obesity preceded low self-esteem but not vice verse among 10 to 11 years old Canadian children. (5)

Built on our previous observations, in the present study, with a nationally representative survey data of National Longitudinal Survey of Children and Youth (NLSCY) in Canada, structural equation modeling were applied to further investigate the longitudinal impacts of change in body mass index at 2-year follow-up and change in school performance at 2-year follow-up on 4-year late self-esteem, and reveal the underlying mechanisms of the relationships, which is essential for planning prevention and designing intervention of childhood overweight and obesity. To the best of our knowledge, this is the first study to apply structural equation modeling to longitudinal data demonstrating the mental health consequences of childhood overweight and obesity, and herewith combining structural equation modeling with epidemiological principles pertaining to causality and to reveal the underlying mechanism.

5.2.0 Research Design and Methods

5.2.1 Study Design

The data were from Statistics Canada's National Longitudinal Survey of Children and Youth, a prospective cohort survey that described the development, well-being and health of Canadian children and youth. The survey began in 1994/95 (cycle 1) with the enrollment of 22,831 children aged 0 to 11 years. Every two years since then, participants have been re-interviewed. Interviewers administered the survey in person and on phone to the child and to the person most knowledgeable about the child. 91.3% were the mothers, 8.2% were the fathers and 0.5% was other persons. (6)

5.2.2 Sample

This study targeted 2,879 subgroup children who were aged 10 or 11 in cycle 1 since only these children completed a self-esteem questionnaire. Follow-up information was available in cycle 2 for 2,018 of these children when they were aged 12 or 13, and for 1,806 of them in cycle 3 when they were aged 14 or 15. Subsequent cycles did not provide comparable information on self-esteem. 1,806 of the children was the final sample in this study. The baseline weighted prevalence estimates of sociodemographic and other characteristics of participants in analyses were presented in Table 5-1.

Ethics Approval

Statistics Canada gave consent for this study to be performed using confidential micro data from the National Longitudinal Survey of Children and Youth (NLSCY).

5.2.3 Measurement and Evaluation

5.2.3.1 Self-esteem Assessment

A four-item scale was completed by children that assessed their overall self-esteem: (i) "In general, I like the way I am"; (ii)"Overall I have a lot to be proud of"; (iii)"A lot of things about me are good"; and (iv)"When I do something, I do it well." Response options for each item were: false, mostly false, sometimes false/sometimes true, mostly true, and true. These responses were scored as 0, 1, 2, 3 and 4, with the highest score representing good self-esteem, and subsequently we totaled the scores ranging from 0 to

16. The inter-item reliability (Cronbach's alpha) of the 4 items was 0.73 indicating sufficient internal consistency of the self-esteem questionnaire.

5.2.3.2 Body Mass Index Evaluation

The person most knowledgeable about the child reported the child's height and weight, from which body mass index (kilograms divided by height in meters squared) was calculated.

5.2.3.3 School Performance Assessment

The person most knowledgeable was asked to assess the child's school performance based on their knowledge of his or her schoolwork and report cards: (i) very poor; (ii) poor; (iii) average; (iv) good; and (v) very good.

5.2.3.4 Other Independent Variables

Adjustments were made to account for other independent variables known to influence the relationships between BMI, school performance and self-esteem: gender of the child, rural or urban residence, household income, parental education, and the child's physical activity and screen time covered using computer, playing video games and viewing television. (5)

Gender of the child, rural or urban residence, household income, and parental education were available from a questionnaire completed by the person most knowledgeable about the child. Household income was divided into four categories: lowest (less than $20,000 a year), lower- middle ($20,000 to $39,999), upper-middle ($40,000 to 59,999), and highest ($60,000 or more). Parental education was classified as: (i) less than secondary graduation; (ii) secondary graduation; (iii) some postsecondary; and (iv) postsecondary graduation.

Children answered questions about how frequently they participated in physical activity and screen time. Two physical activity questions were asked: when not at school, did the child engage in any sports or other physical activities, and were any sport activities coached by an instructor in the last year. Regarding screen time two questions were asked: How many times per week (not including school hours) did the child use a

computer or play video games and how many times did it watch television. For this analysis, responses to both questions of physical activity and of screen time were included in one single indicator respectively that was categorized as follows: (i) twice a week or less; (ii) three or four times a week; (iii) five to seven times a week; and (iv) eight or more times a week.

5.2.4 Data Analysis

Structural Equation Modeling (SEM) is an advanced multivariate statistical process with which a researcher can construct theoretical concepts, hypothesize and test a theory about their relationships, consider both direct and indirect effects of variables on one another, and take into account measurement errors. (7-10) Using method of longitudinal structural equation modeling, we currently hypothesized and tested a conceptual model to characterize the relationships between three dependent variables - body mass index, school performance, and self-esteem. In particular, we were interested in measuring the longitudinal direct, indirect, and total effects of changes in 2-year late body mass index and school performance on 4-year late self-esteem.

In the analyses, body mass index at 2-year follow-up (cycle 2), school performance at 2-year follow-up (cycle 2) and self-esteem at 4-year follow-up (cycle 3) were considered as endogenous concepts (dependent variables). All other variables from baseline (cycle 1) were considered as exogenous concepts (independent variables). Details of variables and their coding in longitudinal SEM were presented in Table 5-2.

According to the findings of our previous cross-sectional structural equation modeling (Chapter 2 and Chapter 4), specifically body weight affecting self-esteem negatively and school performance affecting self-esteem positively, body weight no effect on school performance and self-esteem effect neither on body weight nor on school performance, our initial hypothesis of current longitudinal model including two relational combinations between three endogenous concepts (i) change of body mass index at 2-year follow-up had a direct negative effect on 4-year late self-esteem; (ii) change of school performance at 2-year follow-up had a direct positive effect on 4-year late self-esteem. We considered

all direct and indirect confounding influence from baseline (cycle 1), which included child's gender, rural or urban residency, household income, parental education, child's physical activity, screen time, BMI, school performance and self-esteem (the exogenous concepts) on three endogenous concepts. Upon failure to confirm this model, i.e. when the goodness-of-fit χ^2 test statistic revealed a statistically significant difference between the hypothesized model and the observations, we adjusted the model hypothesis in light of the model evidence and reduced the number of causal links between exogenous concepts and three endogenous concepts by removing the relational combination with the poorest fit. Subsequently, we tried to confirm the reduced model. We repeated this process until we confirmed the existence of a model with a satisfactory goodness of fit.

Took into account both design effects inherent in the complex survey design, as well as non-response bias, the analyses were weighted by using cycle 3 relative longitudinal sampling weights that were prepared by Statistics Canada.

Pairwise missing was used in structural equation models that were constructed by using LISREL, version 8.0.

5.3.0 Results

Two hypothesized models have been demonstrated that fit the data well. Both of them confirmed the existence of two temporal relationships among the three endogenous concepts, one of which was statistically significant.

5.3.1 Longitudinal Impacts and Underlying Mechanisms in the First Model

In the first model, results showed that (i) The effect of change of BMI at 2-year follow-up on change of self-esteem at 4-year follow-up was not statistically significant (β =0.031; 95% CI: -0.075, 0.014). (ii) Change of school performance at 2-year follow-up affected change of self-esteem at 4-year follow-up in a statistically significant manner, whereby an increase of one unit of school performance was associated with an increase of 0.332 (95% CI: 0.161, 0.502) in self-esteem.

The unstandardized structural coefficients (and 95% CIs) of the exogenous concepts with each of the three endogenous concepts are shown in Table 5-3. Figure 5-1 displays those statistically significant structural coefficients of exogenous concepts with endogenous concepts (γ's) and those structural coefficients between endogenous concepts (β's). Appendix 3 shows the original output of Figure 5-1. The goodness-of-fit χ^2 test statistic (Table 5-3, P = 0.1829) indicates that the obtained model provides a satisfied agreement between hypothesized theories and observations.

The significant unstandardized structural coefficients of β's and γ's and the underlying mechanisms of the relationships are interpreted as follows: In addition to a direct negligible effect of 2-year late BMI on 4-year late self-esteem and a positive direct effect of 2-year late school performance on 4-year late self-esteem of magnitude 0.332, the model revealed a direct positive effect of baseline BMI on 2-year late BMI of magnitude 0.585, and of baseline self-esteem on 4-year late self-esteem of magnitude 0.374. Baseline school performance, on the other hand, had an indirect positive effect on 4-year late self-esteem via 2-year late school performance and was estimated at $0.206=0.619\times0.332$, and its direct effect on 2-year late school performance was estimated at 0.619. Male gender had a positive direct effect on 4-year late self-esteem of magnitude 1.187 and a negative indirect effect mediated through 2-year late school performance of magnitude $-0.055=-0.167\times0.332$, yielding a net positive total effect of magnitude $1.132=1.187-0.055$, which indicated that boys, compared to girls, reported a higher self-esteem at 4-year follow-up, whereas they had a poorer school performance at 2-year follow-up. The direct, indirect (via school performance) and total net positive effects of household income on 4-year late self-esteem were estimated at 0.294, $0.027=0.080\times0.332$, and $0.321=0.294+0.027$, respectively. Physical activity had a positive direct effect on 4-year late self-esteem of magnitude 0.232 and screen time had a negative direct effect of magnitude -0.500.

5.3.2 Longitudinal Impacts and Underlying Mechanisms in the Second Model

Good fit by a model consistent with one causal hypothesis does not rule out equally good fit by another model consistent with a different causal hypothesis. (7-10) We obtained

another statistically satisfied model that reconfirmed the existence of two temporal relationships among the three endogenous concepts, one of which was statistically significant. Results showed that (i) The effect of change of BMI at 2-year follow-up on change of self-esteem at 4-year follow-up was not statistically significant ($\beta = 0.007$; 95% CI: -0.039, 0.025). (ii) Change in school performance at 2-year follow-up affected change in self-esteem at 4-year follow-up in a statistically significant manner, whereby an increase of one unit of school performance was associated with an increase of 0.476 (95% CI: 0.342, 0.653) in self-esteem.

The unstandardized structural coefficients (and 95% CIs) of the exogenous concepts with each of the three endogenous concepts are presented in Table 5-4. Figure 5-2 displays those statistically significant structural coefficients of exogenous concepts with endogenous concepts (γ's) and those structural coefficients between endogenous concepts (β's). Appendix 4 shows the original output of Figure 5-2. The goodness-of-fit χ^2 test statistic (Table 5-4, P = 0.0871) indicates that the obtained model also provides a satisfied agreement between hypothesized theories and observations.

The significant unstandardized structural coefficients including β's and γ's and the underlying mechanisms of the relationships in the second model are explained as follows: Consistent with the first model, change in 2-year late BMI had a negligible direct effect on 4-year late self-esteem, whereas change in 2-year late school performance had a significantly positive direct effect on 4-year late self-esteem of magnitude 0.476. Baseline BMI had a positive direct effect on 2-year late BMI of magnitude 0.586 and a negative direct effect on 4-year late self-esteem of magnitude –0.1105. Baseline school performance had a positive direct effect on 4-year late self-esteem of magnitude 0.221 and a positive indirect effect via 2-year late school performance of magnitude $0.295=0.619\times0.476$, yielding a net positive total effect of $0.516=0.221+0.295$. Baseline self-esteem had a direct positive effect on 4-year late self-esteem and was estimated at 0.397. Gender had a positive direct effect on 4-year late self-esteem of magnitude 1.122 and a negative indirect effect mediated through 2-year late school performance of magnitude $-0.089=-0.186\times0.476$, yielding a net positive total effect of magnitude

1.033=1.122-0.089. Consistence with the first model, relative to girls, boys had a poorer school performance at 2-year follow-up, but reported a higher self-esteem at 4-year follow-up. Residence only had a indirect negative effect on 4-year late self-esteem through 2-year late school performance of magnitude -0.047=-0.099×0.476, showing that relative to children living in urban, rural children had a poorer school performance at 2-year follow-up, whereas they did report a higher self-esteem at 4-year follow-up. The direct, indirect (via school performance) and total net positive effects of household income on 4-year late self-esteem were estimated at 0.288, 0.037=0.078×0.476, and 0.325=0.288+0.037, respectively.

One important difference between our two models was that in the second model change of baseline BMI negatively impacted on 4-year late self-esteem in a statistically significant manner, whereby an increase of one unit of BMI was associated with a decrease of 0.060 (95% CI: -0.095, -0.024) in self-esteem. However, when baseline physical activity and screen time were included in the first model, this effect did not exist. The observation implied that the effect of baseline BMI on 4-year late self-esteem could be modified by baseline physical activity and screen time.

5.4.0 Discussion

In the present study, we demonstrated two longitudinal models. Both of them consistently indicated that there was a negligible effect of change in 2-year late BMI on 4-year late self-esteem. On one hand, the findings implied that if the damage of self-esteem occurred in overweight and obese children, it could not be reversed automatically over time. Therefore we should address the prevention of childhood overweight and obesity, and suggest that interventions designed to reduce childhood overweight and obesity should include mental health program focusing on improving the self-esteem of overweight and obese children. On the other hand, as our previous study (Chapter 3) did reveal that baseline BMI predicted low self-esteem at 4-year follow-up, but not 2-year follow-up, we consider that, in the current study, with data covering only a 2-year period (from cycle 2 to cycle 3) could be a potential reason for failing to confirm change in 2-year late BMI

affecting 4-year late self-esteem in a significant manner. In other words, more long-term studies are needed to demonstrate the above relationship.

The second model of our study revealed a negative direct effect of baseline BMI on 4-year late self-esteem, which was in agreement with our previous study using regression (Chapter 3). We noticed that such effect disappeared by putting baseline physical activity and screen time into the model, which implied that body mass index could be just an intermediate step and increased physical activity and less screen time were the true factors in promoting self-esteem in children. However, in our first model baseline physical activity and screen time did not have an indirect effect on 4-year late self-esteem via change of 2-year late BMI. As some previous researchers have reported that physical activity did not significantly improve BMI status in a short-term, (11, 12) here, again, we consider that 4-year follow-up study (from cycle 1 to cycle 3) could be not long enough to confirm that a more active lifestyle could reduce body weight and lead ultimately to higher self-esteem.

Evidence from this study strongly supported the association between academic performance of children in school and their self-esteem. It supported several other studies that have investigated over time the positive relation between academic performance and self-esteem, as a way of establishing a causality of this association. (13) Skaalvik and Hagtvet (14) found evidence that performing well in school in one year led to higher self-esteem in the next year. The sample was followed up after a period of 18 months, generating credible evidence in this regard. The association between school performance and self-esteem was further supported by Bowles (15) who specifically measured self-esteem after the semester for which he obtained school grades. Our study and all these studies seem to indicate that self-esteem is a result, not a cause, of doing well in school.

The current study provided further justification for promoting physical activity among children. In addition to the well-documented physical health benefits of an active lifestyle, higher physical activity and less screen time have positive impacts on the mental health of children (i.e. development of a positive self-esteem). According to a review that

included 23 randomized controlled trials, the authors concluded that exercise may only have short term beneficial effects on self-esteem in children. (16) Few longitudinal studies have assessed the directionality of the relationship between physical activity and self-esteem in children over an extended time period. We only identified one research project, with 197 girls in the United States where participation in physical activity and their self-esteem was assessed when they were 9, 11, and 13 years old. Schmalz et al reported that a significant lag time of the effect of physical activity on self-esteem was observed. Specifically, higher physical activity at ages 9 and 11 years predicted higher self-esteem at ages 11 and 13 years respectively, controlling for covariates. (17) Our study showed that more physical activity and less screen time directly promoted 4-year late self-esteem, which adds more new evidence on how important an active lifestyle is in promoting good mental health of children.

Boys scored higher on self-esteem than girls over time, which is consistent with other studies, (18-21) while some studies have not described gender differences in self-esteem in children. Girls may have a lower self-esteem, compared to boys, as the literature states that they generally assess their physical appearance and athletic competence more negatively. (22) They experience more societal pressure to be thin and are more often evaluated by many based upon their appearance due to the greater socio-cultural emphasis on physical appearance for them. (22) Unfortunately, girls that have the ideal weight are still under significant societal pressure to continue to look and act this way, as the ideal of "thin" girls is highly promoted in many parts of the developed world. It is therefore easy to imagine that they often become overwhelmed with a sense of approval one's physical appearance.

Our two models consistently demonstrated that household income had direct and indirect positive effects on 4year late self-esteem, which is in agreement with the previous study reporting that there was a positive relationship between higher social class and higher self-esteem. (23) Researchers have indicated a list of family factors which had been found to have adverse effects on the self-esteem of children and adolescent, including

lower social class, economic hardship and neighborhood unemployment, etc. (24-27) The current study adds new evidence supporting these previous reports.

The key strengths of this study included the use of a longitudinal study design. With three cycles of measurement, we were able to examine the longitudinal relationships between body mass index, school performance and self-esteem. To the best of our knowledge, this is the first study that has measured these relationships using a longitudinal structural equation modeling. The fact that both direct and indirect effects could be examined simultaneously in one model makes structural equation model more useful than regression analysis, since instead of demonstrating only one direct effect in regression, structural equation modeling can handle more than one, which further provide details in underlying mechanisms of the relationships. (10) For example, consideration of both direct and indirect effects in our two models led to an interesting revelation in examining the relationship between gender and 4-year late self-esteem, i.e. the direct effect of gender on 4-year late self-esteem was estimated to be positive, which was offset by an indirect negative effect through 2-year late school performance. Had we not considered indirect effects, we would have been led to believe that gender had a strong positive effect on 4-year late self-esteem when in fact the overall effect was reduced by 2-year late school performance. In other words, using regression we only find that, compared to girls, boys reported a high self-esteem 4-year late (Chapter 3), whereas using structural equation model we also know that, relative to girls, boys had a poor school performance at 2-year late resulting in a negative effect on their 4-year late self-esteem. We would miss examining such a fundamental issue at a greater depth, as it is difficult to achieve with traditional statistical methodologies. Furthermore, applying structural equation modeling to longitudinal data and combining it with epidemiological principles pertaining to causality make our study more original and stronger.

There are several limitations of this study. First, findings are only applicable to children aged 10 or 11 years. As a result, the study observation should be related only to this age group of children. Second, we did not have access to measurements of the children's height and weight at all times of the assessments. Body mass index was therefore

determined using a calculation of parent-reported weights and heights of their children with possible error. School performance was self-evaluated by parents and self-esteem was reported by young children whose responses were all subject to recall bias and error. Finally, loss to follow-up occurred at the 2-year and 4-year follow-up. However, the data did not show differential loss to follow-up in regard to body weight and self-esteem. (5) Additional research could expand on this study by using more objective longitudinal data (e.g., measured height, weight and school performance) covering longer time (e.g., from 5 to 10 years) causal relationship linking change in body mass index and change in lagged self-esteem among diverse children.

5.5.0 Conclusions

This study examined longitudinal impacts of changes in 2-year late body mass index and school performance on 4-year late self-esteem in a sample of Canada nationally represent children who were primarily 10 or 11 years old. The results showed that change in 2-year late body mass index had a negligible effect on 4-year late self-esteem, and that the negative direct effect of baseline body mass index on 4-year late self-esteem could be modified by active lifestyle. However, more longer-term studies are needed to confirm the above results. The present study demonstrated that school performance did have a direct positive effect on the development of self-esteem, highlighted the necessity of promoting active lifestyle in children as a method of fostering positive self-esteem, and provided justification for emphasizing the priority of improving self-esteem for girls and children with lower socioeconomic status. In order to prevent and reduce the potential negative mental health consequences of childhood overweight and obesity, a long-term comprehensive intervention strategy is suggested focusing on promoting active living, as well as mental health, specifically self-esteem, as a whole.

Table 5-1 Baseline Weighted Prevalence Estimates of Sociodemographic and Other Characteristics of Participants in Structural Equation Model

Independent Variable	Longitudinal SEM
Participants, *N*	1806 (100.00%)
Gender (%)	
Girl	49.96
Boy	50.04
Residence (%)	
Urban	78.92
Rural	21.08
Household income (%)	
< $ 20,000	3.87
$ 20,000 – 39,999	21.91
$ 40,000 – 59,999	32.52
≥ $60,000	41.71
Parental education (%)	
Less than secondary graduation	5.60
Secondary graduation	13.73
Some postsecondary	2.46
Postsecondary graduation	56.08
Weekly physical activity (%)	
Twice or less	31.87
Three or four times	28.99
Five to seven times	33.48
Eight or more times	5.66
Weekly screen time (%)	
Twice or less	4.70
Three or four times	8.29
Five to seven times	55.70
Eight or more times	31.32
BMI (%)	100.00
School performance (%)	
Poor or very poor	3.04
Average	22.02
Good or very good	74.94
Self-esteem score (%)	100.00

Note: [a] SEM: Structural Equation Model

[b] The data includes children with available information in Cycle 1 (1994/1995), in Cycle 2 (1996/1997) and with available information on self-esteem in Cycle 3 (1998/1999) participating in the Canadian National Longitudinal Survey of Children and Youth (NLSCY).

Table 5-2 Variables and their coding in structural equation models

		Longitudinal models
Cycle 1 variable:		
Body-weight status	BMI from PMK reported height and weight	weight (kg)/height (m^2) (considered continuous)
School performance	Reported by PMK	1=Very poor 2=Poor 3=Average 4=Good 5=Very good
Self-esteem	Student report	Score ranges from 0 to 16 (considered continuous)
Gender	PMK report	1=Girl, 2=Boy
Residence	PMK report	1=Urban, 2=Rural
Annual household income	PMK report	1=Less than $20,000 2=$20,000 to $39,999 3=$40,000 to $59,999 4=$60,000 or more
Parental education	PMK report	1= Less than secondary graduation 2= Secondary graduation 3= Some postsecondary 4= Postsecondary graduation
Weekly physical activity	Student report	1= Twice or less 2= Three or four times 3= Five to seven times 4= Eight or more times
Weekly screen time	Student report	1= Twice or less 2= Three or four times 3= Five to seven times 4= Eight or more times
Cycle 2 variable:		
Body-weight status	BMI from PMK reported height and weight	weight (kg)/height (m^2) (considered continuous)
School performance	Reported by PMK	1=Very poor 2=Poor 3=Average 4=Good 5=Very good
Cycle 3 variable:		
Self-esteem	Student report	Score ranges from 0 to 16 (considered continuous)

Note: Cycle 1, baseline
BMI, Body Mass Index
PMK, the Person Most Knowledgeable about the child

Table 5-3 Longitudinal structural coefficients and 95% confidence intervals of exogenous variables with three endogenous variables (model one)

Exogenous Variables at Cycle 1 (baseline)	BMI at Cycle 2	School Performance at Cycle 2	Self-esteem at Cycle 3
Gender	0.203 (-0.178, 0.584)	**-0.167 (-0.263, -0.072)**	**1.187 (0.855, 1.519)**
Residence	0.082 (-0.376, 0.541)	-0.100 (-0.124 , 0.105)	-0.226 (-0.620, 0.168)
Household income	-0.028 (-0.250, 0.195)	**0.080 (0.024, 0.136)**	**0.294 (0.101, 0.487)**
Parental education	0.014 (-0.201, 0.228)	0.017 (-0.036, 0.071)	-0.026 (-0.211, 0.159)
Physical activity	-0.012 (-0.211, 0.187)	-0.033 (-0.082, 0.016)	**0.232 (0.061, 0.403)**
Screen time	0.022 (-0.229, 0.233)	-0.020 (-0.082, 0.043)	**-0.500 (-0.717, -0.284)**
BMI	**0.585 (0.528, 0.643)**	—	—
School performance	—	**0.619 (0.568, 0.670)**	—
Self-esteem	—	—	**0.374 (0.311, 0.438)**

Note: [a] The model had a 0.9986 goodness-of-fit index (GFI) and its comparative GFI was equal to 0.9980. The goodness-of-fit Chi-Square was 10.1007 (d.f.=7; *P*=0.1829). Root Mean Square Error of Approximation (RMSEA) =0.0186.

[b] We did not assume the existence of a direct causal relationship between baseline school performance and BMI at 2-year follow-up, between baseline self-esteem and BMI at 2-year follow-up, between baseline BMI and school performance at 2-year follow-up, between baseline self-esteem and school performance at 2-year follow-up, between baseline BMI and self-esteem at 4-year follow-up and between baseline school performance at four year follow-up and self-esteem. Models that included these relationships failed the GFI criterion, indicating a poor agreement between hypothesized model and observations.

[c] BMI, body mass index.

[d] For the original output, please refer to Appendix 3.

Table 5-4 Longitudinal structural coefficients and 95% confidence intervals of exogenous variables with three endogenous variables (model two)

Exogenous Variables at Cycle 1 (baseline)	BMI at Cycle 2	School Performance at Cycle 2	Self-esteem at Cycle 3
Gender	**0.204 (0.002, 0.405)**	**-0.186 (-0.240, -0.132)**	**1.122 (0.931, 1.313)**
Residence	0.085 (-0.187, 0.356)	**-0.099 (-0.166, - 0.031)**	**-0.237 (-0.001, -0.473)**
Household income	-0.028 (-0.160, 0.104)	**0.078 (0.045, 0.110)**	**0.288 (0.173, 0.404)**
Parental education	0.013 (-0.114, 0.261)	0.018 (-0.014, 0.050)	-0.004 (-0.151, 0.107)
BMI	**0.586 (0.552, 0.620)**		**-0.060 (-0.095, -0.024)**
School performance		**0.619 (0.589, 0.649)**	**0.221 (0.085, 0.357)**
Self-esteem			**0.397 (0.359, 0.436)**

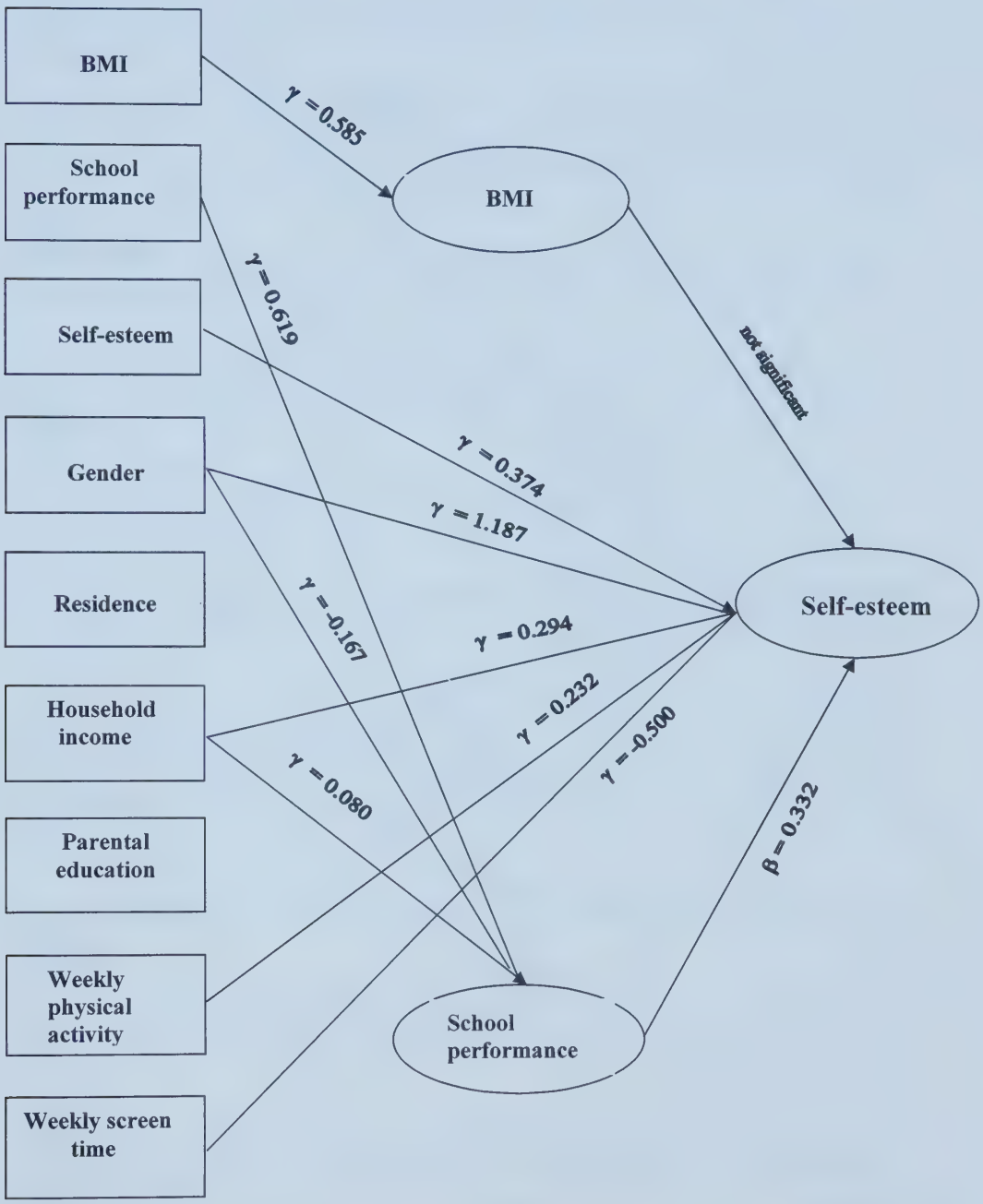
Note: [a] The model had a 0.9994 goodness-of-fit index (GFI) and its comparative GFI was equal to 0.9988. The goodness-of-fit Chi-Square was 9.6090 (d.f.=5; P=0.0871). Root Mean Square Error of Approximation (RMSEA) =0.0164.

[b] We did not assume the existence of a direct causal relationship between baseline BMI and school performance at 2-year follow-up, between baseline school performance and BMI at 2-year follow-up, between baseline self-esteem and BMI at 2-year follow-up, and between baseline self-esteem and school performance at 2-year follow-up. Models that included these relationships failed the GFI criterion, indicating a poor agreement between hypothesized model and observations.

[c] BMI, body mass index.

[d] For the original output, please refer to Appendix 4.

Figure 5–1 Longitudinal structural coefficients of BMI in cycle 2, school performance in cycle 2, self-esteem in cycle 3 and baseline exogenous variables (model one)



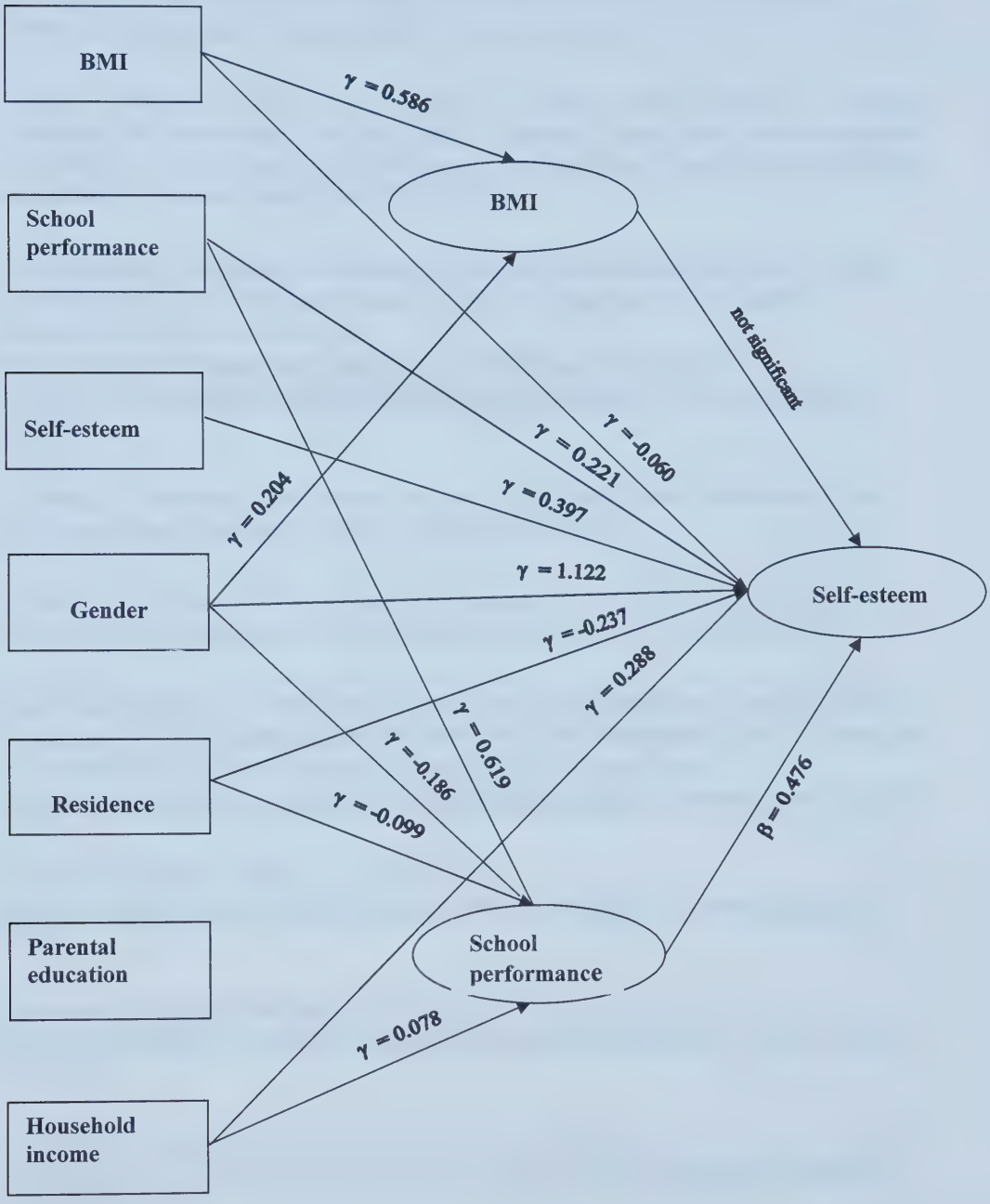
* γ : Structural coefficient between exogenous and endogenous variables

† β : Structural coefficient between endogenous variables

‡ Only the statistical significant structural coefficients are displayed

§ For the original output, please refer to Appendix 3.

Figure 5-2 Longitudinal structural coefficients of BMI in cycle 2, school performance in cycle 2, self-esteem in cycle 3 and baseline exogenous variables (model two)



* γ : Structural coefficient between exogenous and endogenous variables

† β : Structural coefficient between endogenous variables

‡ Only the statistical significant structural coefficients are displayed

§ For the original output, please refer to Appendix 4.

5.6.0 References

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Chapter 6 – Summary

6.1.0 Introduction

Increases in the prevalence of childhood overweight and obesity have become a public health problem with heavy economic burden.(1-4) In developed countries, the prevalence of childhood overweight and obesity is not only increasing, it is accelerating.(5, 6) While considerable research has examined the physical health consequences of childhood overweight and obesity, for example, hypertension, heart disease, diabetes and some cancers, (7, 8) evidence to determine the effect of overweight and obesity on mental health and school performance is limited. There is even less research focused on the interrelations of childhood overweight, school performance and self-esteem simultaneously. Self-esteem development is important for children, as it orients children' behavior to meet environmental demands and new developmental challenges, plays an essential role in children's social, emotional, behavioral and personality development, and is referred to as an early marker of mental health in adulthood. (9, 10) Low self-esteem can create anxiety, stress, loneliness and increased likelihood for depression, lead to problems with friendships and relationships, and even increased vulnerability to many self destructive behaviors. (11-14) Poor school performance will result in limited educational attainment impair career opportunities and in the long-term lead to lower socioeconomic status with reduced prospects for good health. (15,16) Therefore more attention should focus on the effects of childhood overweight and obesity on self-esteem and school performance in order to provide more holistic and effective consideration for diverse interventions.

In the present thesis we have classified the directionality of the associations between body mass index, self-esteem and school performance simultaneously, assessed the cross-sectional associations and temporal relationships of overweight, school performance and self-esteem, and examined whether change of body mass index and change of school performance can affect lagged self-esteem and how the effects occurred in Canadian children who were primarily 10 or 11 years old. Findings of this thesis provide better understanding of the mental health consequences of childhood overweight and obesity,

and give new evidence for intervention and policy making. The strategic direction is essential in primary prevention, as it will assist us when we make plans in the future to structure the interventions, allocate resources, recruit faculty, invest in infrastructure, and with input from many interested stakeholders of our society.

6.2.0 Statement of Principal Findings

The principal findings of this thesis consisted of the results of four studies. In the first study (Chapter 2), we revealed the directions of the associations between body weight, school performance and self-esteem, and found that both childhood body weight and school performance affected self-esteem but where no other statistically significant effects between the three variables existed. Subsequent logistic regression showed that obese students, relative to normal weight students, were more likely (1.44; 95% CI: 1.12 - 1.84), and students with good school performance, relative to those performing poor, were less likely (0.39; 95% CI: 0.26 - 0.58), to have low self-esteem. Active living and diet quality had positive effects on both school performance and self-esteem. (17)

The second study (Chapter 3) investigated longitudinal relationships between excess weight, poor school performance and low self-esteem; in addition to reconfirming the cross-sectional associations with a different survey data by using logistic regression. Results showed that excess body weight predicted the development of low self-esteem over a four-year period, and that low self-esteem did not predict lagged excess weight. Weekly physical activity significantly positively predicted the development of self-esteem over a 4-year period. The study evidence gathered here lends some support to the view that the obese child is more vulnerable and has an increased risk of low self-esteem. (18)

The third study (Chapter4) was designed to reconfirm the directionality of the associations between body weights, school performance and self-esteem in a sample of Canada nationally represent children sample who were primarily 10 or 11 years old. Despite of difference in measurements of body weight, self-esteem and school

performance, findings were in agreement with our previous observations in Nova Scotia (CLASS, Chapter 2), which consistently demonstrated that excess body weight and poor school performance significantly reduced the level of self-esteem and that no other statistically significant associations between the three variables existed. The study further highlighted the necessity of promoting active lifestyles among children as a method of reducing body weight, as well as fostering positive self-esteem, and provided justification for emphasizing the priority of improving self-esteem for children with socioeconomic disadvantaged families.

In the last study (Chapter 5), we applied structural equation modeling to a longitudinal date to examine the impacts of change in body mass index and change in school performance on lagged self-esteem and reveal the underlying mechanisms. The study found that change in 2-year late body mass index had a negligible effect on 4-year late self-esteem, whereas change in 2-year late school performance had a direct positive effect on 4-year late self-esteem. The study again highlighted the necessity of promoting active lifestyle as a method of fostering positive self-esteem, and supported the priority of improving self-esteem for girls and for children with lower socioeconomic status.

In summary, the principal findings of this thesis suggested that obesity was an independent determinant for low self-esteem, and it predicted 4-year late low self-esteem in 10 or 11 years old children. However, change in 2-year late body mass index did not significantly affect 4-year late self-esteem. Childhood overweight and obesity did not seem to have an independent effect on school performance. Poor school performance was an independent risk of low self-esteem. Both more physical activity and less screen time improved the level of self-esteem. Diet quality was significantly associated with self-esteem and school performance in a positive manner. Girls and children with low socioeconomic status were in high risk of low self-esteem.

6.3.0 Meaning of the Study and Implications for Policymakers

Self-esteem is the focus of this thesis because it has been identified as a predictor of many other constructs that constitute psychosocial well-being. Higher levels of self-esteem are associated with increased self-efficacy, body image, and leadership, and reduced levels of depression and anxiety (9, 10). Few studies has simultaneously examined the directionality of the associations between body weight, school performance and self-esteem, tested the temporal relationships and further revealed the underlying mechanisms in elementary school children. Given the high rates of overweight and obesity in this population, these are important questions to address. The lack of detailed information on the consequences of mental health and school performance in childhood overweight and obese impedes the development of effective interventions, as the conclusive evidence of causal relationships between the three variables will ensure more effective intervention and more reasonable use of limited intervention resources.

The implications for public health of this thesis are as follows: (i) Excess body weight, less active lifestyle and poor diets are risk factors of low self-esteem. Children in Western countries went through decades of changes towards increased rates of excess body weight, less physically active, more screen time lifestyle, and deteriorating diets. The findings of the study therefore suggest that as a result of these temporal lifestyle changes, the prevalence of low self-esteem may be increasing over time. (ii) Childhood obesity predicts subsequent low self-esteem, but not vice versa. The downstream consequences may be important, given that other studies have shown low self-esteem may lead to underachievement, increased vulnerability to drug and alcohol abuse, and in some cases, self-destructive behavior, and to be associated with poor mental health later in life, such as anxiety, stress, loneliness, and greater likelihood of depression.(11-14) These mental health issues may be underappreciated consequences of childhood obesity. (iii) Obesity did not seem to have an independent effect on school performance. However, the established determinants of obesity, poor diet and inactivity were found to affect both self-esteem and school-performance. In other words, the study findings further add to the rationale to promote active lifestyle and healthy eating among children and youth as this will prevent chronic diseases and improve mental health. (iv) Change in 2-year late body mass index only had a negligible effect on 4-year late self-esteem implies that if the

damage of self-esteem occurred in children, it could not be reversed automatically. Therefore, to emphasize the prevention of childhood overweight and obesity is never overdoing. (v) Our cross-sectional SEM (Chapter 4) found that more physical activity and less screen time not only reduce body weight directly, but indirectly via reduce body weight promoting positive self-esteem. However, longitudinally the study (Chapter 5) did not support this inference. In light of 4-year follow-up period could be not long enough to reveal the above longitudinal effects, more longer-term studies and interventions, at least beyond 4 years, should be designed and completed. (□) The findings provide further justification for emphasizing the priority for prevention initiatives targeting girls and children performing poor and of socioeconomic disadvantaged families.

Taken together, a long-term comprehensive intervention is suggested to prevent and reduce childhood overweight and obesity. Promotion of active living and healthy eating with consideration of gender and socioeconomic differences may therefore be beneficial to reduce overweight, improve self-esteem in children, and prevent chronic diseases and foster mental health in future adulthood.

6.4.0 Strengths and Weaknesses in Relation to Other Studies, Discussing Particularly Differences in Results

The findings of this thesis are important for several reasons. First, we were perhaps the first study on the interrelationships of body weight, school performance and self-esteem simultaneously in the young age group of 10 or 11 year olds. We observed that excess body weight has an independent negative effect on self-esteem, which is in agreement with observation of studies that did not include consideration of school performance (19, 20). Our observations of the positive effects of school performance and physical activity on self-esteem have also been reported previously (21, 22). However, our observations of the negative effect of TV/computer screen time and the positive effect of diet quality on self-esteem have not been reported previously. The findings add to the rationale to promote active living and healthy eating in childhood as this will improve not only physical health, but also mental health.

Second, two population-based databases with large sample size provide sufficient statistical power for analysis, and cross-sectional and longitudinal study designs together enable us to examine the cross-sectional associations and temporal relationships between body weight, school performance and self-esteem. Several previous studies have reported an inverse relationship between obesity and self-esteem in children, (19, 20) but these studies were cross-sectional and could not establish whether obesity affects self-esteem or whether self-esteem affects obesity. A small body of longitudinal studies showed that the increases in BMI were significantly associated with unfavorable changes in self-esteem. (23-25) Children who were overweight and obese at baseline had lower self-esteem at follow-up, (23, 24) whereas low self-esteem did not appear to predict the development of obesity. (24) As well, findings of our two cross-sectional studies were similar to those of other cross-sectional analyses, showing that body weight and self-esteem are inversely related, (17) and our longitudinal results support the view that excess body weight precedes the development of low self-esteem, rather than the reverse. (18)

Third, two analysis approaches, logistic regression and structural equation modeling were used together in the study. Relative to regression analysis, structural equation modeling has the ability to analyze two or more dependent variables simultaneously, consider both direct and indirect effects among dependent variables and independent variables, and that a variable can play a double role in a structural model (independent and dependent) makes it more useful than regression, since instead of performing two regressions one structural equation model will do. In this thesis, we used structural equation modeling to determine the directionality of the associations between body mass index, school performance and self-esteem simultaneously. Perhaps one of the most attractive features of structural equation modeling is that it offers directionality of the associations between two or more dependent variables. (26, 27) Our cross-sectional structural equation models consistently confirmed that there was a statistically significant negative association between body weight and self-esteem, even when the potential effect of school performance on self-esteem was adjusted. To the best of our knowledge, no previous studies have reported such a finding.

In this thesis, unstandardized structural coefficients are reported. For the unstandardized coefficients, we can interpret changes of variables in terms of the original units (e.g. 'points' for self-esteem, kg/m*m for BMI, and level of performance for school performance); however we cannot directly compare the size of the coefficients to answer the question like "which one is the most important?" For the standardized coefficients, which are the coefficients resulted from using standardized variables in the analysis (z score variables transformed from the original variables by subtracting by the mean and dividing by the standard deviation), it is possible to make such comparisons, because all of the variables are expressed in standard score forms and can be directly interpreted as effect sizes. That is to say, we might say things like: if the BMI increased by one standard deviation, then the Self-esteem might decrease by 0.05 a standard deviation. However, people could be confused by such an interpretation, since the value of one standard deviation, for the same variable, always changes across different study populations and sample sizes. Therefore, unstandardized coefficients are used in our studies.

According to the directions of the associations revealed by our cross-sectional SEM between body weight, school performance and self-esteem, we subsequently used logistic regression, with self-esteem as a binary outcome, to quantify the magnitudes of the associations. Our cross-sectional findings showed that the odds to report low self-esteem for obese children were 44% (Chapter 2) and 84% higher (Chapter 3), respectively, than the odds for normal weight children in two population-based studies. Longitudinal analysis is the best one to explore the temporal relationship in epidemiology. Our longitudinal regression showed that the odds to report low self-esteem for obese children were 82% higher than the odds for normal weight children in 4-year late (Chapter 3). Due to the differences in statistical assumption and coding of variable, we were unable to directly compare the results of our structural equation model and regression. However, the findings from our two analysis approaches consistently demonstrated that the obese children were at higher risk of low self-esteem.

Most previous studies have suggested that self-esteem is positively correlated with academic or school performance. (21, 28, 29) One review consisting of 12 cross-sectional studies and 6 follow-up studies concluded that self-esteem is a result, not a cause, of doing well in academic or school performance. (21) Another study found that self-esteem has a very weak or no impact on subsequent academic or school performance. (28) Our study reconfirmed the previous studies that the effect of school performance on self-esteem is significantly positive, and expanded the previous findings that change of 2-year late school performance can significantly affect change of 4-year late self-esteem.

A previous literature review reported that exercise at least has short term beneficial effects on self-esteem in children. (22) Few longitudinal studies have assessed the directionality of the relationship between physical activity and self-esteem in children. We only identified one study, with 197 non-Hispanic white girls whose participation in physical activity and their self-esteem were assessed when they were 9, 11, and 13 years old, a significant lagged effect of physical activity on self-esteem was identified. Specifically, higher physical activity at ages 9 and 11 years predicted higher self-esteem at ages 11 and 13 years respectively. (30) Our study supported that active living was positively associated with self-esteem, and further indicated that more physical activity and less TV/computer screen time could promote self-esteem in a period of 4 years.

A number of studies have found that there were significant gender effects on self-esteem, some favoring girls but more favoring boys, or with boys having higher global self-esteem. (31-33) Other studies reported that there was not significant gender difference in global self-esteem in children and adolescents, and the self-esteem of girls is at least as high as that of boys. (34, 35) Our cross-sectional studies did not find significant gender differences in self-esteem, whereas our longitudinal analyses showed that boys had a higher self-esteem than girls over time. The possible reasons could be related to that self-esteem tended to increase in boys and decrease in girls over time, (36) and that gender differences in attitudes toward physical appearance and obesity, and parental attitudes and beliefs about body weight could cause additional harm to a child's self-esteem, especially for girls, beyond that which is directly associated with body size. (37)

6.5.0 Strengths and Weaknesses of the Study

The key strengths of this thesis were that it was a large population-based research covering one provincially and another nationally representative sample of Canadian children. Objective measures of height and weight and results from standardized literacy test were important strengths of the CLASS data. The longitudinal design in the NLSCY data made it possible to investigate temporal relationships between body weight status, school performance and self-esteem. Analyses were weighted using population sampling weights and bootstrapping weights in the NLSCY data, which accounted for complex survey design effects and non-response bias. Two analysis approaches including logistic regression and structural equation modeling were applied together made our findings more convincing. Finally, all analyses in the research have adjusted for the influence of potential confounders.

The weaknesses of this research were as follows: All databases used in the present thesis were secondary data. Although it was speedy and economic, the selection of which data to collect, the quality of data gathered, how data were recorded were all predetermined, and we had little or no control over them. The global self-esteem measurement failed to capture the main sources from which self-worth were derived. Self-esteem was reported by children in both CLASS and NLSCY datasets, and height, weight and school performance were reported and evaluated by parents in the NLSCY data. Assessment tools for these variables are based on self-report and therefore prone to error and recall bias. Selection bias and information bias, specifically volunteer bias and non-response bias, happened in two databases. Only children aged 10 or 11 years in the studies limits us to generalize the study conclusions. Body mass index cutoff points established for children by the International Obesity Task Force were applied in the current research. These cutoffs do not allow the identification of those who were underweight. Caution is therefore warranted in extrapolating the findings to underweight children. Another potential limitation included bias stemming from differential loss to follow-up in the NLSCY data. However, an attrition analysis did not show differential loss to follow-up

according to self-esteem and body weight status. Finally, nutrition and dietary patterns could not be considered in Chapter 3, 4 and 5 because they were not collected in the NLSCY data. Such information may be important for future research, given other findings showing that healthy eating is positively associated with school performance (29, 38) and self-esteem among children. (17) In addition, no collection of some important variables in both CLASS and NLSCY datasets was another limitation. For example, without the information of child's intelligence quotient, we were unable to study the association between intelligence quotient and school performance.

Additional research could expand on this thesis by using more objective longitudinal data (e.g., measured height, weight and school performance), covering longer time periods (e.g., from 5 to 10 years) and using a multi-component self-esteem questionnaire among diverse children.

6.6.0 Future Research

Several issues should be addressed in the future research. First of all, why childhood overweight and obesity is related to the reduction self-esteem? In theory, people have high or low self-esteem depend at least part on how others regard and treat them. (20) For some overweight or obese children, since others devalue them, they may devalue themselves, as they fall short of internalized social standards for acceptable body weight. (39, 40) The inverse relation should be stronger for children who perceive themselves as overweight than for children who actually are overweight. (39, 40) Aside from realization and feeling of adverse weight status, the influence of social culture and norm, attitude and appraisal of peer and family members could also put pressure on children who are overweight and obese. In fact, such circumstances may have mediated the longitudinal relationship between body weight and low self-esteem observed in our studies, a possibility that might be examined in future research. A few studies have reported that weight-based teasing from peers or family members was consistently associated with low self-esteem, even after controlling for actual body weight in children. (41) Children whose parents judged them to be more overweight than expected had lower appearance self-esteem.(42) Body size stigmatization from society and teasing from peers could

result in victimization of children with overweight and obese, which in turn significantly reduces or destroys the self-esteem of overweight and obese children. (43) Furthermore, it is not clear if overweight and obese children believed that the others' responses to them could have been based on prejudice, and overweight and obesity was not their fault, which can partly works as self-esteem protective strategies. We need more studies to reveal and confirm above mentioned mechanisms.

According to the multidimensional, hierarchical model advocated by leading researchers self-esteem could be assessed by incorporating components such as the global self (or self-esteem): a person's overall positive versus negative feelings about the self, the physical appearance self (or body esteem/satisfaction), the athletic self, the academic self, the social self , the occupational self and the family self. (44-48) As self-esteem measurement used in the current research fails to capture the main sources from which self-worth are derived, we suggest multi-component self-esteem questionnaire to be use in the future research. For instance, the Harter Self-Perception Profile for Children (Harter, 1985) is one widely used self-esteem scale for children aged 8-14 years old, includes six areas believed to be important for self-esteem and there are six items in each area. The six areas are scholastic competence, social acceptance, athletic competence, physical appearance, behavioral conduct, and global self-worth. (49, 50) With such an assessment tool, we can capture which aspects of self-esteem are related to childhood overweight and which ones to school performance, as well as get directions of intervention with great accuracy.

We recommend high quality longitudinal and intervention studies to further confirm the present findings. For example, the present childhood obesity epidemic has urged many jurisdictions to prepare for, or have already implemented, school-based promotion of active living and healthy eating. These initiatives also provide a unique opportunity to prospectively evaluate the importance of active living, healthy eating and body weight for self-esteem and for school performance, and to study whether the school intervention program could be of benefit to children beyond the decrease of overweight – to improve self-esteem and school performance. Furthermore, whether a comprehensive school

intervention program consisting of not only healthy eating and physical activity, but mental health education as well could prevent overweight and improve self-esteem in children, and prevent adulthood disease and promote mental health later in their life.

Finally, in addition to self-esteem, a systematic study of the impact of childhood overweight on the mental health covering emotional disorders, anxiety, depression, behavioral problems, friendship, as well as health problems including smoking, drinking, and drug use and sex behavior, is worthy efforts to pursue, as these evidences are essential to provide more multifaceted public health approach and effective intervention for children population.

6.7.0 References

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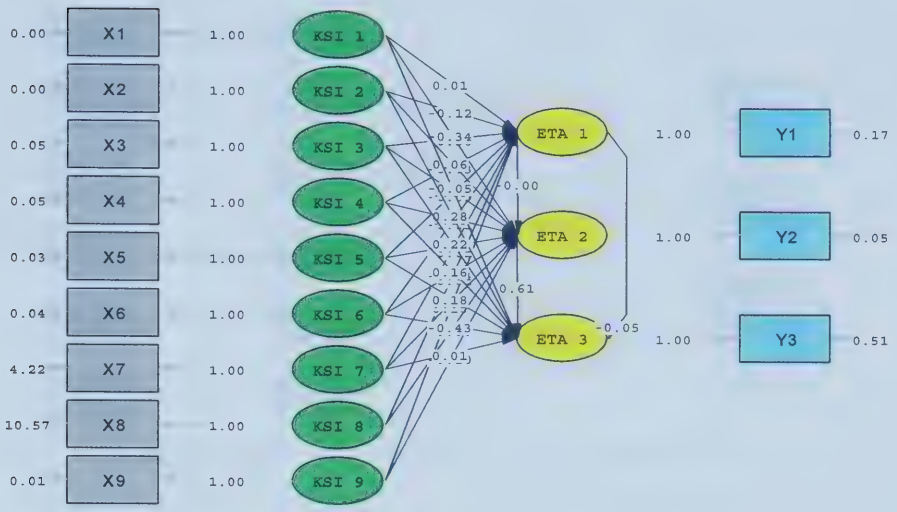
Appendix 1: Figure 2-1 output of structural coefficients of BMI, school performance, self-esteem and exogenous variables

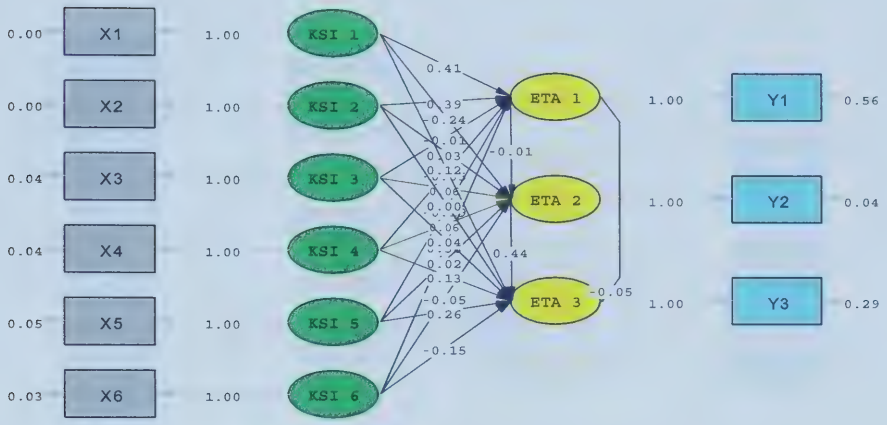


Chi-Square=0.4455, df=2, P-value=0.8003, RMSEA=0.0000

Note: X1,Gender
X2,Residence
X3,Household income
X4,Parental education
X5,Physical activity
X6,Sedentary activity
X7,Diet quality index
X8,School neighborhood level income
X9,School-level academic performance

Y1,Body Mass Index (BMI)
Y2,School performance
Y3,Self-esteem

Appendix 2: Figure 4-1 output of cross-sectional structural coefficients of BMI, school performance, self-esteem and exogenous variables

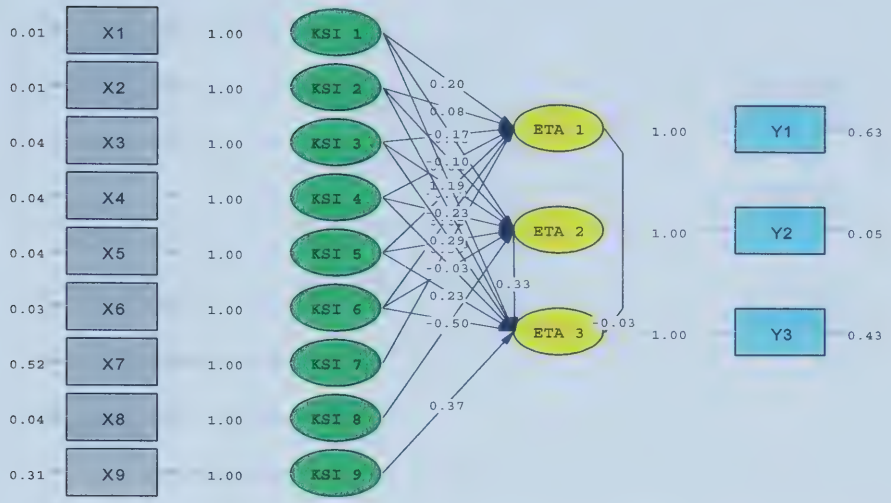


Chi-Square=0.2817, df=1, P-value=0.5956, RMSEA=0.0000

Note: X1,Gender
X2,Residence
X3,Household income
X4,Parental education
X5,Physical activity
X6,Screen time

Y1,Body Mass Index (BMI)
Y2,School performance
Y3,Self-esteem

Appendix 3: Figure 5-1 output of longitudinal structural coefficients of BMI in cycle 2, school performance in cycle 2, self-esteem in cycle 3 and baseline exogenous variables (model one)



Chi-Square=10.1007, df=7, P-value=0.1829, RMSEA=0.0186

Note: X1,Baseline gender

X2,Baseline residence

X3,Baseline househole income

X4,Baseline parental education

X5,Baseline physical activity

X6,Baseline screen time

X7,Baseline Body Mass Index (BMI)

X8,Baseline school performance

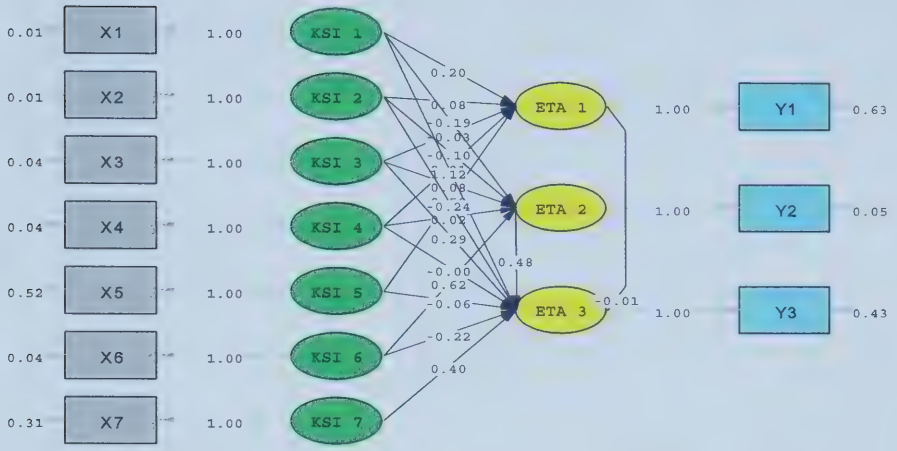
X9,Baseline self-esteem

Y1,Body Mass Index (BMI) in cycle 2

Y2,School performance in cycle 2

Y3,Self-esteem in cycle 3

Appendix 4: Figure 5-2 output of longitudinal structural coefficients of BMI in cycle 2, school performance in cycle 2, self-esteem in cycle 3 and baseline exogenous variables (model two)



Chi-Square=9.6090, df=5, P-value=0.0871, RMSEA=0.0164

Note: X1,Baseline gender
X2,Baseline residence
X3,Baseline household income
X4,Baseline parental education
X5,Baseline Body Mass Index (BMI)
X6,Baseline school performance
X7,Baseline self-esteem

Y1,Body Mass Index (BMI) in cycle 2
Y2,School performance in cycle 2
Y3,Self-esteem in cycle 3

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